A framework for the design, development and implementation of technology platforms in the South African health context

by

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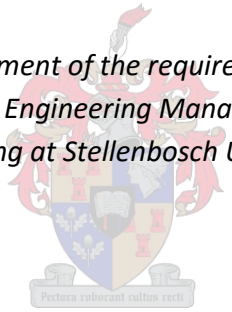

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Declaration

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Abstract

Healthcare in South Africa is in dire need of effective and sustainable solutions. Low life expectancy, high maternal and neonatal mortality, the impact of HIV and increasing non-communicable diseases are compounded by the limited availability of skilled healthcare professionals. Initiatives such as the Sustainable Development Goals aim to address these issues by working towards good health and well-being particularly in developing countries. Technology platforms can provide much-needed solutions to these above-mentioned issues. Ways in which such platforms can provide solutions include the ability to communicate information, remotely monitor patients, collect and analyse data and enable personalised medicine. Therefore, technology platforms could potentially be a valuable asset in the mission to improve healthcare in developing countries such as South Africa.

However, the healthcare sector has been resistant to platform adoption due to characteristics such as sensitive data and high cost of failure. Research has confirmed the differences in platform implementation across countries, but a focus on implementation in the context of developing countries such as South Africa is limited. A framework for the design, development and implementation of technology platforms in the South African health context could therefore contribute to the gap in research as well as provide a practical tool that platform owners could use to potentially increase the adoption of platforms in this context.

This study aimed to develop a framework that can be used in the design, development and implementation of technology platforms in the South African health context. In order develop the framework, the researcher developed eight research objectives that were grouped into two main phases. The first phase included the framework development, while the second comprised the framework evaluation, specifically within the South African health context. Subsequently, a suitable research design was developed and implemented that enabled the researcher to meet the project objectives.

The research design for this study was based on the Grounded Theory Conceptual Framework Analysis process developed by Jabareen (2009). The process focused on mapping and investigating data sources, categorising and integrating concepts, synthesising these concepts into a framework and iteratively evaluating the framework. The research design comprised four overarching parts that aligned with the Conceptual Framework Analysis process. The first part of the research design aimed to establish the context and aims of the study. Thereafter the focus shifted to formulating the preliminary framework and its subsequent progressive evaluation process. The concluding part of the study presented and discussed the final framework and management tool.

The first step in the research included a systematic literature review to develop an overall picture of the relevant research and identify possible gaps. This included identifying the key concepts related to technology platforms in innovation ecosystems as well as the multidisciplinary nature of this research. As a part of the systematic literature review results, the void of related research in Africa, challenges for platform owners, the three different platform ecosystem actors as well as several guiding principles were uncovered.

Subsequently, a conceptual literature review was done to further investigate key concepts and ideas. This included an understanding of the ecosystem metaphor and thirteen fundamental characteristics of platforms and ecosystems. The context in which such a platform ecosystem would operate was investigated in terms of the ecosystem actors and the South African health context. The literature review also included the investigation and analysis of existing frameworks, models and tools (FMTs) related to platform design and platform and ecosystem management. The FMTs provided much-

needed insight into the structure, use and layout of the proposed framework and highlighted gaps in these existing FMTs currently available to platform owners.

The preliminary framework, constructed as a result of the systematic and conceptual literature reviews, had to be evaluated. The evaluation process comprised three components, namely a theoretical case study, semi-structured interviews and an industry-based case study. Subsequent to each of these components, the framework was modified and adapted. The components of the evaluation process also accounted for significant insights into the South African health context. As a result of the evaluation process, the final framework was developed.

The final framework can be used by platform owners as a management tool. This tool comprises six canvasses: (1) Pre-use Canvas, (2) Overview Canvas, (3) Platform Owner Canvas, (4) Developer Canvas, (5) End-user Canvas and (6) Platform Development Canvas. These canvasses are divided into two dimensions, namely an ecosystem dimension and a platform development dimension. The ecosystem dimension includes a canvas for each of the three platform ecosystem actors. These ecosystem canvasses provide insights and questions regarding each of the ecosystem actors. The Platform Development Canvas aims to lead the platform owner into action and guides the platform development process. This Canvas comprises five parts, namely the platform core, the desired ecosystem and environment, the design of the platform and governance, the managing and operation and evolution of the platform and ecosystem.

The framework and tool make a contribution to research. The framework was designed to be a practical tool with a user-centric focus. The framework therefore provides a platform owner with insight into the ecosystem actors and practical elements to design and manage the platform and ecosystem. The framework was also developed taking into account typical challenges that a platform owner would face. Another unique contribution is that the framework draws from two platform perspectives, namely the engineering and the economic perspectives. These perspectives are mostly viewed in isolation despite the fact that when combined, they provide a more holistic understanding of platforms. The final contribution is the tailoring of the framework for the South African health context. Particularly the End-user Ecosystem Canvas transformed significantly throughout the evaluation phases to suit the South African health context.

The final framework and tool therefore met the project objectives. The framework should however continuously evolve to remain relevant and usable to platform owners and to sustain its use as a tool to facilitate the adoption of technology platforms in the South African health context.

Opsomming

Gesondheidsorg in Suid-Afrika het 'n geweldige behoefte aan effektiewe en volhoubare oplossings. Lae lewensverwagting, hoë moeder- en neonatale sterftes, die impak van MIV en toenemende nie-oordraagbare siektes word vererger deur die beperkte beskikbaarheid van geskoolde gesondheidswerkers. Inisiatiewe soos die 'Sustainable Development Goals' is daarop gemik om hierdie kwessies aan te spreek deur te werk aan goeie gesondheid en welsyn, veral in ontwikkelende lande. Tegnologieplatforms kan die nodige oplossings bied vir die bogenoemde kwessies. Maniere waarop sulke platforms oplossings kan bied, sluit in die vermoë om inligting te kommunikeer, pasiënte op afstand te monitor, data te versamel en te analiseer en persoonlike medisyne in staat te stel. Daarom kan tegnologieplatforms potensieel 'n waardevolle bate wees in die missie om gesondheidsorg in ontwikkelende lande soos Suid-Afrika te verbeter.

Die gesondheidsorgsektor het egter weerstand teen platformaanneming, weens eienskappe soos sensitiewe data en die hoë koste van mislukking. Navorsing het die verskille in platform implementering regoor lande bevestig, maar 'n fokus op implementering in die konteks van ontwikkelende lande soos Suid-Afrika is beperk. 'n Raamwerk vir die ontwerp, ontwikkeling en implementering van tegnologieplatforms in die Suid-Afrikaanse gesondheidskonteks kan dus bydra tot die gaping in navorsing, asook 'n praktiese hulpmiddel bied wat platform eienaars kan gebruik om potensiële platforms in die konteks te verhoog.

Hierdie studie het gemik om 'n raamwerk te ontwikkel wat gebruik kan word in die ontwerp, ontwikkeling en implementering van tegnologie-platforms in die Suid-Afrikaanse gesondheidskonteks. Om hierdie raamwerk te ontwikkel, het die navorser agt navorsingsdoelwitte ontwikkel wat in twee hooffases gegroepeer is. Die eerste fase het die raamwerkontwikkeling ingesluit, en die tweede deel het die raamwerkevaluering ingesluit, spesifiek binne die Suid-Afrikaanse gesondheidskonteks. Vervolgens is 'n geskikte navorsingsontwerp ontwikkel en geïmplementeer wat die navorser in staat gestel het om die projekdoelwitte te bereik en die navorsingsvraag te beantwoord.

Die navorsingsontwerp vir hierdie studie is baser op die Jabareen-ontwikkelingsproses (2009) wat gegrond is op die 'Grounded Theory' benadering. Die proses het gefokus op die soek en ondersoek van databronne, die kategorisering en integrasie van konsepte, die konsepte in 'n raamwerk te sintetiseer en die raamwerk iteratief te evalueer. Die navorsingsontwerp bestaan uit vier dele wat in lyn was met die konseptuele raamwerk ontwikkelings-proses. Die eerste deel van die navorsingsontwerp het ten doel om die konteks en doelstellings van die studie vas te stel. Daarna het die fokus verskuif na die formulering van die voorlopige raamwerk en die daaropvolgende progressiewe evalueringsproses. Die laaste gedeelte van die studie het die finale raamwerk en bestuursinstrument ingesluit en bespreek.

Die eerste stap in die navorsing sluit 'n sistematiese literatuuroorsig in om 'n algehele prentjie van die relevante navorsing te ontwikkel en moontlike leemtes te identifiseer. Dit sluit in die identifisering van die sleutelkonsepte wat verband hou met tegnologie-platforms in innovasie-ekosisteme asook die multidissiplinêre aard van hierdie navorsing. As deel van die sistematiese literatuuroorsigresultate is die leemte van verwante navorsing in Afrika, uitdagings vir platform-eienaars, die drie verskillende platform-ekosisteem-akteurs en verskeie riglyne uitgelig.

Daarna is 'n konseptuele literatuuroorsig gedoen om sleutelbegrippe en idees verder te ondersoek. Dit sluit in 'n begrip van die ekostelselmetafoor en dertien fundamentele eienskappe van platforms en ekosisteme. Die konteks waarin so 'n platform-ekosisteem sou funksioneer, is ondersoek in terme van die ekosisteem-akteurs en die Suid-Afrikaanse gesondheidskonteks. Nog 'n element in die literatuuroorsig was die ondersoek en analise van bestaande raamwerke, modelle en hulpmiddels (FMT's) wat verband hou met platformontwerp en platform- en ekosisteembestuur. Die FMT's het

nodige insig gegee aan die struktuur, gebruik en uitleg van die voorgestelde raamwerk en gapings in die bestaande FMT's wat tans aan platform-eienaars beskikbaar is, uitgelig.

Die voorlopige raamwerk, gebou as gevolg van die sistematiese en konseptuele literatuuroorsigte, moes geëvalueer word. Die evalueringsproses bestaan uit drie komponente, naamlik 'n teoretiese gevallestudie, semi-gestruktureerde onderhoude en 'n industrie-gebaseerde gevallestudie. Na aanleiding van elk van hierdie komponente is die raamwerk aangepas. Die komponente van die evalueringsproses het ook beduidende insigte in die Suid-Afrikaanse gesondheidskonteks verskaf. As gevolg van die evalueringsproses is die finale raamwerk ontwikkel.

Die finale raamwerk kan potensieel deur platform-eienaars gebruik word as 'n bestuursinstrument. Hierdie instrument bestaan uit ses ‘canvasses’: (1) Pre-use Canvas, (2) Overview Canvas, (3) Platform Owner Canvas, (4) Developer Canvas, (5) End-user Canvas and (6) Platform Development Canvas. Die instrument het twee dimensies, naamlik 'n ekosisteemdimensie en 'n platformontwikkelingsdimensie. Die ekosisteemdimensie sluit 'n ‘Canvas’ in vir elk van die drie platform-ekosisteem-akteurs. Die ekosisteem-‘canvasses’ bied insigte en vrae in elk van die akteurs onderskeidelik, gebaseer op hul eienskappe en rolle in die ekosisteem. Die Platformontwikkelings ‘Canvas’ is daarop gemik om die eienaar van die platform in aksie te lei en begelei die platformontwikkelingsproses. Hierdie ‘canvas’ bestaan uit vyf dele, naamlik die vestiging van die platformkern, die verlangde ekosisteem en omgewing, die ontwerp van die platform en bestuursbenadering, die bestuur en werking van die platform en evolusie van die platform en ekosisteem.

Die raamwerk en instrument maak 'n bydrae tot navorsing. Die raamwerk is ontwerp om 'n praktiese instrument met 'n gebruikersgesentreerde fokus te wees. Die raamwerk verskaf dus 'n platform eienaar met insigte oor die akteurs binne die ekosisteem en praktiese elemente om die platform en ekosisteem te ontwerp en te bestuur. Die raamwerk is ook ontwikkel met inagneming van tipiese uitdagings wat 'n platform-eienaar sou ondervind. Nog 'n unieke bydrae is dat die raamwerk uit twee platformperspektiewe, naamlik die ingenieurs- en die ekonomiese perspektiewe, saamgestel is. Hierdie perspektiewe word meestal in isolasie gesien, ondanks die feit dat hulle gekombineerd 'n meer holistiese begrip van platforms bied. Die finale bydrae is die aanpassing van die raamwerk vir die Suid-Afrikaanse gesondheidskonteks. Veral die Eindgebruiker-ekosisteem ‘Canvas’ het aansienlik deur die evalueringsfases getransformeer om by die Suid-Afrikaanse gesondheidskonteks te pas.

Die finale raamwerk en hulpmiddel het dus die projekdoelwitte bereik. Die raamwerk moet egter voortdurend aangepas word om relevant en bruikbaar vir platform-eienaars te bly en om die gebruik daarvan as 'n instrument om die aanneming van tegnologie-platforms in die Suid-Afrikaanse gesondheidskonteks te bevorder.

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"*Thus says the LORD to you, 'Do not be afraid and do not be dismayed at this great horde, for the battle is not yours but God's*" – 2 Chronicles 20:15.

May whatever I continue to do with this degree, always glorify Him.

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List of Canvasses

List of Acronyms and Abbreviations

AI	Artificial Intelligence
AIDS	Acquired immunodeficiency syndrome
API	Application Programming Interface
App	Application
AWS	Amazon Web Services
BMC	Business Model Canvas
B2B	Business to Business
B2G	Business to Government
CDA	Clinical Document Architecture
CEO	Chief Executive Officer
CFA	Conceptual Framework Analysis
CPU	Computer Processing Unit
C#	Criteria number
DHIS2	District Health Information Software 2
eHealth	Electronic Health
EHR	Electronic Health Record
EMR	Electronic Medical Record
FMT	Framework, model or tool
GSMA	Global System for Mobile Communication
GT	Grounded Theory
GQM	Goal Question Metric Approach
HC	Healthcare
HIE	Health Information Exchange
HIG	Human Interface Guide
HIPAA	Health Insurance Portability and Accountability Act of 1996
HIV	Human Immunodeficiency Virus
HIS	Health Information System
HL7	Health Level 7 International
HMIS	Health Management Information Systems
HNSF	Health Normative Standards Framework

HW	Hardware
IAMOT	International Association for Management of Technology
ICASA	Independent Communications Authority of South Africa
ICD-10	10th revision of the International Statistical Classification of Diseases and Related Health Problems
ICT	Information and Communication Technology
IDE	Integrated Development Environment
IoT	Internet of Things
IP	Intellectual Property
IS	Information Systems
ISO	International Standards Organisation
IT	Information Technology
IVR	Interactive Voice Response
KPI	Key Performance Indicator
LMIC	Low-Middle Income Countries
MAMA SA	Mobile Alliance for Maternal Action South Africa
MDGs	Millennium Development Goals
mHealth	Mobile Health
MoH	Ministry of Health
MS	Microsoft
MUSiC	Metrics for Usability Standards in Computing
MVP	Minimum Viable Product
M&E	Monitoring and Evaluation
NCD	Non-communicable Diseases
NDA	Non-Disclosure Agreement
NDoH	National Department of Health
NGO	Non-governmental organisation
NHI	National Health Insurance
NPR	National Pregnancy register
OpenHIM	Open Health Information Exchange
OS	Operating system
PaaS	Platform as a Service

PACMAD	People At the Centre of Mobile Application Development
PC	Personal Computer
PECO	Platform Ecosystem
PF	Platform
PICO	Participants, Interventions, Comparisons and Outcomes criteria
PO	Platform Owner
PoPI	Protection of Personal Information Act
PPPs	Public-Private Partnerships
REC	Research Ethics Committee
RO	Research Objective
R&D	Research and Development
SaaS	Software as a Service
SA	South Africa
SABEC	South African Conference for Biomedical Engineering
SAIIE	South African Institute for Industrial Engineers
SDG	Sustainable Development Goal
SDK	Software Development Kit
SECO	Software Ecosystem
SECO-SAM	Software Ecosystem Strategy Assessment Model
SITA	State Information Technology Association
SMS	Short Message Service
SPM	Software Product Management
SOA	Service Oriented Architecture
SPO	Software Producing Organisation
SSA	Sub Saharan Africa
SVS	Stock Visibility Solution
SW	Software
TB	Tuberculosis
Tech Stack	Technology Stack
TIS	Technology Innovation Systems
UI	User Interface
UIG	User Interface Guidelines

UK	United Kingdom
UI	User Interface
USSD	Unstructured Supplementary Service Data
WHO	World Health Organization
XMTs	Cross Platform Mobile Development Tools
3D	Three Dimensional

Chapter 1: Introduction

Chapter 1 key objectives:

- Provide the background and motivation of the study
- Define the research problem
- State the research questions and objectives
- Present an overview of the Research Design and Methodology
- Present the main research contributions
- Outline the structure of the document

Chapter 1 outlines the motivation for the research and briefly explains technology platforms, platform ecosystems and how platforms could be used to provide solutions within the South African health context. This background leads to the emergence of the research problem, which is translated into the research questions and objectives. The objectives are followed by the Research Design which indicates how these objectives will be met. The structure of Chapter 1 is illustrated in Figure 1.

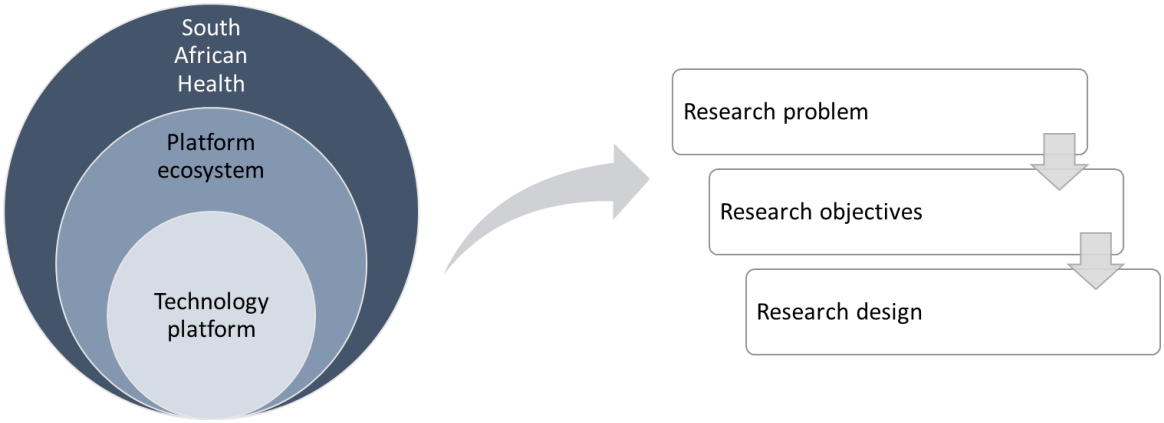


Figure 1: Chapter 1 content description

1.1 Background

Technology is transforming the way we communicate, do business and live through innovative technologies such as 3D printing, blockchain, artificial intelligence (AI), autonomous vehicles, Big Data and the Internet of Things (IoT) [1]. One of the significant technology trends organisations have followed is the adoption of technology platforms [1]. A platform connects people, resources and other participants in an interactive ecosystem within which large amounts of value can both be created and exchanged [2]. Platforms can scale rapidly and efficiently, harness new sources of value creation and shift the organisational focus from internal to its external community [2]. Drivers towards the increasing adoption of platforms include the ease of accessing data, growing digital networks, global connectivity, the Internet of Things and the increasing need for specialisation of products and services [3], [4]. Gawer and Cusumano [5] explain how platforms have grown to platform ecosystems and entered the worlds of social media, books, music, travel, banking, healthcare, energy and transportation across Asia, Europe, Africa, North America and Latin America.

Although technological innovations such as technology platforms have the potential to improve the quality of life for all, the healthcare industry has been resistant to the adoption of technology platforms. According to Parker, Van Alstyne and Choudary [2], this could be due to industry-specific barriers such as the high cost of failure, resource intensity and the high level of regulatory control in the healthcare environment. Specifically in Africa, where primary healthcare is a dire issue [6], information and communication technologies (ICTs), including the use of technology platforms, have

the potential to provide much-needed solutions. The accessibility of large volumes of health-related data obtained from sources such as Electronic Health Records (EHRs), data banks, IoT sensors, other data-obtaining medical devices and mHealth applications [7], can be utilised through technology platforms and thereby aid in improving quality and accessibility of healthcare [8].

1.2 Technology platforms and ecosystems

Parker et al. [2] define platforms in a business context as the provision of an open, participative infrastructure where value-creating interactions can take place between producers and consumers under set governance conditions. The purpose of the platform is to facilitate matches amongst users and enable value creation for all parties through the facilitation of goods, services and social currency exchange.

An interactive ecosystem within which large amounts of value can be created and exchanged can be formed around a central platform [2]. An ecosystem can be defined as "*a network of interconnected organisations, organised around a focal firm or a platform and incorporating both production and use side participants"* [9, p. 2]. More recently, Autio and Thomas [10] defined an innovation ecosystem to be similar to an ecosystem as described before, but with a specific focus on developing new value through innovation. Both these definitions highlight the importance of networks to create value and thus also the network effects in these ecosystems as a source of competitive advantage. To remain competitive in future, platform firms need to invest beyond their short-term goals and extend their focus to the complete ecosystem that sustains the longer-term growth [1]. Figure 2 illustrates the typical participants in a platform ecosystem [11]. The roles of each participant will be investigated in the literature reviews in Chapter 3 and Chapter 4.

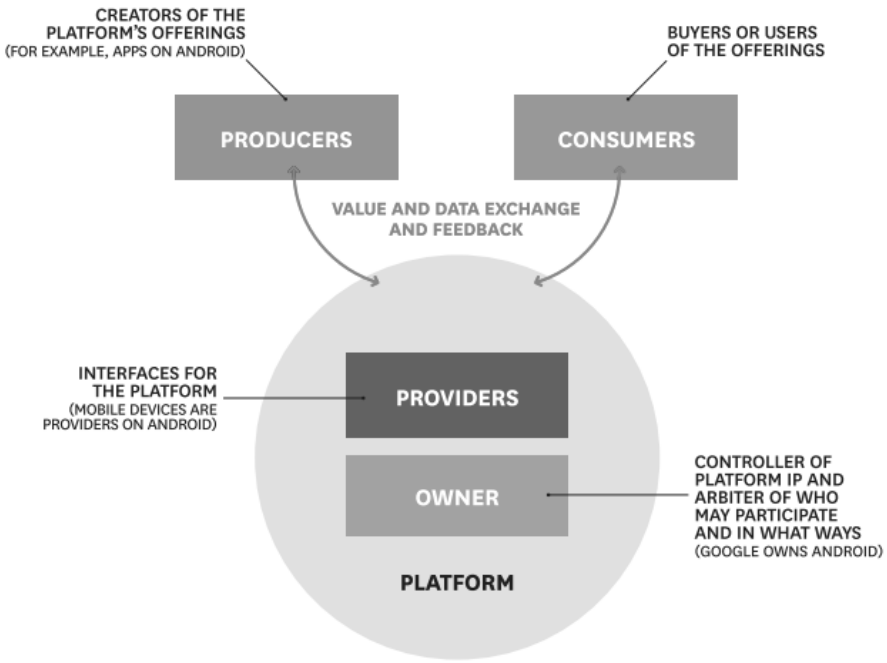


Figure 2: Platform ecosystem participants [11]

A platform owner, as the designer and manager of the technology platform, has a significant responsibility for the platform and for the ecosystem's success and growth [2], [12]. Value creation and distribution within the ecosystem should be enabled and effectively captured. However, this would typically differ from traditional linear business where upstream value creation and downstream value consumption take place [13], [14]. The platform owner should also be aware of the dynamics of competition in the digital age and how this could impact the platform and ecosystem [14]. In addition to these components, the platform owner has to balance elements of the platform and ecosystem

such as maintaining adequate control over the platform and developers without limiting innovation [15]. Subsequently, platform owners have many challenging tasks and have to compromise between trade-offs within the platform and ecosystem.

One of the industries where technology platforms could provide innovative solutions is in health. Technology platform-enabled solutions within the health context can be categorised into three focus areas namely: citizen- , healthcare professional- and institutional support [16]. Three promising enablers for the increased use of these platforms in South Africa (SA) include the rapid advancements in digital technology, the extensive use of mobile devices and widespread connectivity compared to other developing countries [17]–[20]. Platform-enabled healthcare solutions include data collection and transfer and population of databases which can be used to improve point of care decision making abilities [16]. Such platforms can also aid in monitoring the distribution of pharmaceuticals and vaccines as well as with the implementation of pharmacovigilance[1]. Patient education and self-education could also be encouraged through the availability and use of healthcare platforms [8], [21].

Despite platform-enabling factors, there are barriers to the adoption of technology platforms in the health environment. Adding to the previously mentioned barriers to adoption in the healthcare industry are sensitive data [2], [7], lack of standards and interoperability, lack of integration with existing health systems [16], [22] and concerns related to data ownership and governance [23]. The term mHealth refers to the specific use of mobile technology, which often includes technology platforms, to provide solutions within healthcare [24]. Specifically referring to mHealth projects deployed in South Africa, some of the major challenges include the lack of alignment with health system initiatives and strategies, the absence of governmental input, not using open-source solutions and lack of focus on interoperability [16].

1.3 Health and platforms in South Africa

Africa as a developing continent faces many challenges, of which healthcare is probably one of the most pressing. One of the initiatives aiming to improve the overall health of Africans is the Sustainable Development Goals (SDGs). The SDGs comprise 17 goals set by world leaders for a better future. Sustainable Development Goal 3 specifically refers to "*good health and well-being*" [25]. As a part of the monitoring of health for the realisation of the Sustainable Development Goals (SDGs) [25], the World Health Organisation (WHO) publishes regular World Health Statistics. Table 1 indicates particular health statistics for five different countries [26].

Table 1: Health statistics of five different countries (2015 data) [26]

Country	Life expectancy - both sexes (years)	Maternal mortality (per 100 000 live births)	Under-five mortality (per 1 000 live births)	Neonatal mortality (per 1 000 live births)	New HIV infections 15–49 years old (per 1 000 uninfected population)	TB incidence (per 100 000 population)	NCDs Mortality (probability of dying of NCD age 30 - 70 (%))	Skilled healthcare professionals (per 1000 population) 2005–2015
South Africa	62.9	138	40.5	11	14.40	834	26.5	58.8
Mozambique	57.6	489	78.5	27.1	7.07	551	22.9	4.6
Zimbabwe	60.7	443	70.7	21.4	8.84	242	18.4	12.7
United Kingdom	81.2	9	4.2	2.4	-	10	11.0	112.4

[1] World Health Organization defines pharmacovigilance as "*the science and activities relating to the detection, assessment, understanding and prevention of adverse effects or any other drug-related problem*" [215].

Country	Life expectancy - both sexes (years)	Maternal mortality (per 100 000 live births)	Under-five mortality (per 1 000 live births)	Neonatal mortality (per 1 000 live births)	New HIV infections 15–49 years old (per 1 000 uninfected population)	TB incidence (per 100 000 population)	NCDs Mortality (probability of dying of NCD age 30 - 70 (%))	Skilled healthcare professionals (per 1000 population) 2005–2015
Netherlands	81.9	7	3.8	2.4	-	5.8	11.0	116.9

The aim of Table 1 is to highlight the need for innovative health solutions to address issues such as life expectancy, maternal and neonatal mortality rates, Tuberculosis (TB) incidences, non-communicable diseases (NCDs) and the spreading of the Human Immunodeficiency Virus (HIV), particularly in developing countries (shaded rows). Table 1 also contains the same statistics for the United Kingdom and The Netherlands for comparison. The included statistics specifically relate to SDG 3 and its sub-goals. From Table 1 it can be seen that South Africa has the highest rate of new HIV incidences, NCDs mortality and TB incidences. The table therefore highlights the immense gaps between developing and developed countries.

Sustainable Development Goal 3 has thirteen sub-goals relating to good health and well-being. Some of these sub-goals include child, neonatal and maternal mortality, HIV and TB incidences and health worker density [27]. Sustainable Development Goal 9 aims to "*build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation*" [25], which could include the implementation of technological innovations such as technology platforms to aid in the process of working towards realising SDG 3. Figure 3 shows some of the relevant sub-goals of SDG 3.

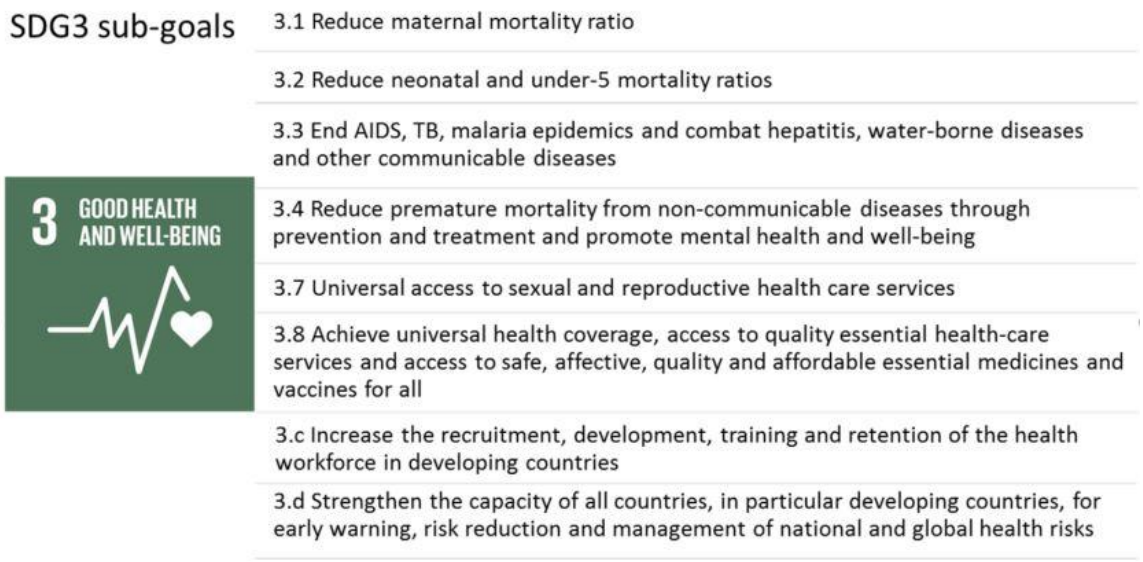


Figure 3: Sustainable Development Goal 3 and its sub-goals [27]

The growth of non-communicable or chronic diseases, especially in developing countries, results in the need for unique healthcare support strategies which may be difficult to deliver [8]. Technology platform applications in health could include the ability to collect data and communicate information, improved remote monitoring of patients, access to larger databases for better decision-making, monitoring of pharmaceuticals and vaccines, patient self-education which can speed up diagnosis and general improved efficiency and point of care services [8], [28]–[31]. Some of these platform-enabled solutions and how they can potentially address health-related issues are shown in Table 2.

Table 2: Health considerations and platform-enabled solutions

Health Aspect (SDG 3 aligned)	Communicate information regarding medical conditions	Telemedicine	Remote monitoring of patients	Better decision-making abilities on site	Stock visibility	Collect and analyse data and form medical database	Personalised medicine availability and collection notifications
Neonatal, maternal and child mortality	✓	✓	✓	✓			✓
HIV/AIDS antiretroviral treatment							✓
Prevention and treatment of NCDs	✓	✓	✓	✓	✓	✓	✓
Inadequate qualified practitioners	✓	✓	✓	✓			
Access to quality healthcare		✓					
Access to medicine, vaccines					✓	✓	✓
Health education and training	✓						
Early warning, risk reduction	✓		✓		✓	✓	

In South Africa, as a result of Apartheid, health services adopted 'separate development' where the public and private healthcare sectors were allocated an unequal distribution of workers and resources. This led to a public healthcare system that was mainly a "*nurse based primary healthcare system*" [32, p. 27]. Limited infrastructure, lack of urban health facilities, resources and qualified healthcare practitioners and the growing disease burden are emphasised by a poor health system, communication and health supply chains [8].

As early as 2009, Harrison [32] predicted the ten biggest challenges for the South African healthcare sector for the 2010–2015 period. These challenges included the availability of healthcare personnel, quality of care, operational efficiency, leadership and innovation. A healthy population contributes to a country's economic growth as it results in a more productive population [8]. Harrison [32] concluded that an improvement in a country's health can result in additional income and thereby improve the living conditions and social infrastructure [21].

Recent research has indicated that utilisation of open technology platforms in healthcare is not just more effective; it is also imperative because they truly support evidence-based practice and continuous quality improvement [33]. A platform thus potentially holds the key to empower patient care teams and drive healthcare innovation. Unfortunately, the studies focusing on healthcare platforms in the developing world remains sparse. Evans and Gawer [5] found that there is a large void in the literature on technology platforms in the African context.

1.4 Research problem

Healthcare in Africa has several major challenges to be addressed in order to improve the quality of life of its citizens, leading to greater equity, economic growth and social stability [8]. Barriers to access and the quality of healthcare are critical issues to address in this process [32]. With the rapid advancement in digital technology and the popularity of mobile devices throughout South Africa, the implementation of technology platforms could provide some of the much-needed solutions. The growth of technology platforms worldwide has inspired research on platform strategy [3], [34], design [35]–[37] and implementation frameworks across several industries.

As discussed previously, the health industry has not been proactive in adopting these platforms, because of its unique characteristics such as the handling of sensitive data and inability of permitting

failures [2]. In addition to this, health platforms specifically tailored to the South African context have not been researched to the same extent as in developed countries. Evans and Gawer's [5] research proved that there is significant disparity between platforms in different regions, motivating the need for research on platforms specifically in the South African context. Frameworks, which are described as *"broad conceptualisations of problems under focus. They help us to organise our thinking and thus, our investigations. A framework provides a general list of variables and can serve as a help to generate questions that have to be addressed*" [38, p. 511], could be useful tools to educate, investigate and further develop platforms within the South African health context. However, there is currently no framework aiding in the design, development and implementation of such a health platform from an ecosystem perspective and within the South African context known to the researcher.

Platforms differ from other traditional approaches as a result of their unique characteristics including the importance of evolution for survival, their compressed evolutionary nature and the crucial relationship between their architecture and governance [3]. This also motivates for a novel management tool to aid in the process of design, development and implementation of such platforms. Figure 4 illustrates how the research problem can be positioned within the Sustainable Development Goals' context where the successful implementation of innovative technologies, such as platforms, could contribute to better health and well-being.

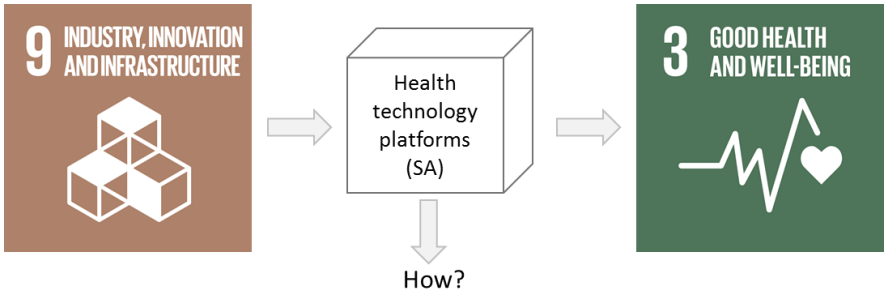


Figure 4: Context of study specifically within the SDGs

1.5 Research questions and objectives

Based on the background and research problem, the research questions and subsequent objectives were formulated. The research questions included three components, namely the main research question, sub-questions and sub-questions considered during the literature reviews. The research objectives were segmented into two phases.

1.5.1 Research questions

The research question that this study aimed to answer is: *How can a framework be developed that focus on the design, development and implementation of technology platforms in the South African health context?*

The following sub-questions are formulated to address the research problem:

- What are the current design strategies and requirements for platform development?
- How can these relate to health-specific applications in developing countries?
- What are the enablers and barriers for health platforms in developing countries?
- How can adoption of platforms in health in developing countries be enabled?

Further sub-research questions for literature review include:

- What are technology platforms and their key characteristics?
- How do technology platforms relate to platform ecosystems?

- What are platform ecosystems and their key characteristics?
- What are the benefits of health technology platforms?
- How can these platforms evolve within their ecosystems?
- Are there differences in platforms in South Africa vs other geographical areas?
- What would a management tool for technology platforms look like?

1.5.2 Research objectives

The objectives of this study were divided into two phases. The first phase focused on theoretical components, whereas the second phase focused on the evaluation component.

Phase 1: The theoretical component aimed to meet the stated objectives through a systematic literature review towards understanding technology platforms. This was followed by an in-depth conceptual literature review in order to understand how these technology platforms operate within their ecosystems, specifically within the South African health context. The conceptual review also included an investigation into existing platform design and management frameworks, models and tools. As a result, a preliminary conceptual framework was developed. The main outcomes of this phase were therefore a systematic literature review, a conceptual literature review and the subsequent preliminary theoretical framework.

Phase 2: The evaluation of the framework was completed in a three-step progressive evaluation process. Firstly, the researcher conducted a theoretical case study investigation into an existing health platform initiative. Secondly, interviews with industry experts were completed to evaluate the content of the framework and to identify any missing concepts. Thereafter an industry-based case study was carried out. During the industry-based case study, the framework was applied in practice to determine its usefulness as a platform management tool.

The two phases of the study aimed to address specific research objectives (ROs):

Phase 1: Develop a preliminary framework to guide the design and development of technology platforms in the South African health context:

- RO1: Review the fundamental concepts of technology platforms from an ecosystem perspective through conducting a systematic literature review.
- RO2: Establish the context and requirements of technology platforms within their ecosystems and the dynamics of the ecosystem actors though conducting a conceptual literature review.
- RO3: Investigate and assess current frameworks, models and tools relevant to platform and ecosystem design and management.
- RO4: Deduce a preliminary framework to aid in the design, development and implementation of these platforms.

Phase 2: Evaluate, adapt and refine the framework into a management tool. This phase of the research project focused on evaluating the framework developed in Phase 1:

- RO5: Use an existing South African health platform to gain understanding and modify the preliminary framework prior to its evaluation in industry.
- RO6: Evaluate the content of the preliminary theoretical framework through interviews with experts in industry and formulate an adapted framework.
- RO7: Test the usefulness of the framework as a management tool through a case study.
- RO8: Present a management tool for the design, development and implementation of technology platforms in the South African health context.

1.6 Research design overview

A Grounded Theory (GT) inspired method for developing a conceptual framework was followed in this project. This approach was proposed by Jabareen [39] as the Conceptual Framework Analysis (CFA) process. The study comprised four main parts which were linked with the CFA process. The first part included a literature overview and background, as well as a systematic literature review. Part two included the conceptual literature review and had the preliminary (inventory) framework as outcome. Part three included the evaluation and adaption of the framework. The fourth and final part presented the final framework and management tool as the main outcome of this project. Figure 5 indicates the four main parts and each of their sub-components. The main outcomes of each part are also indicated by the bullet points. Chapter 2 entails the detailed research design and approach taken to meet each of the phase one and phase two project objectives.

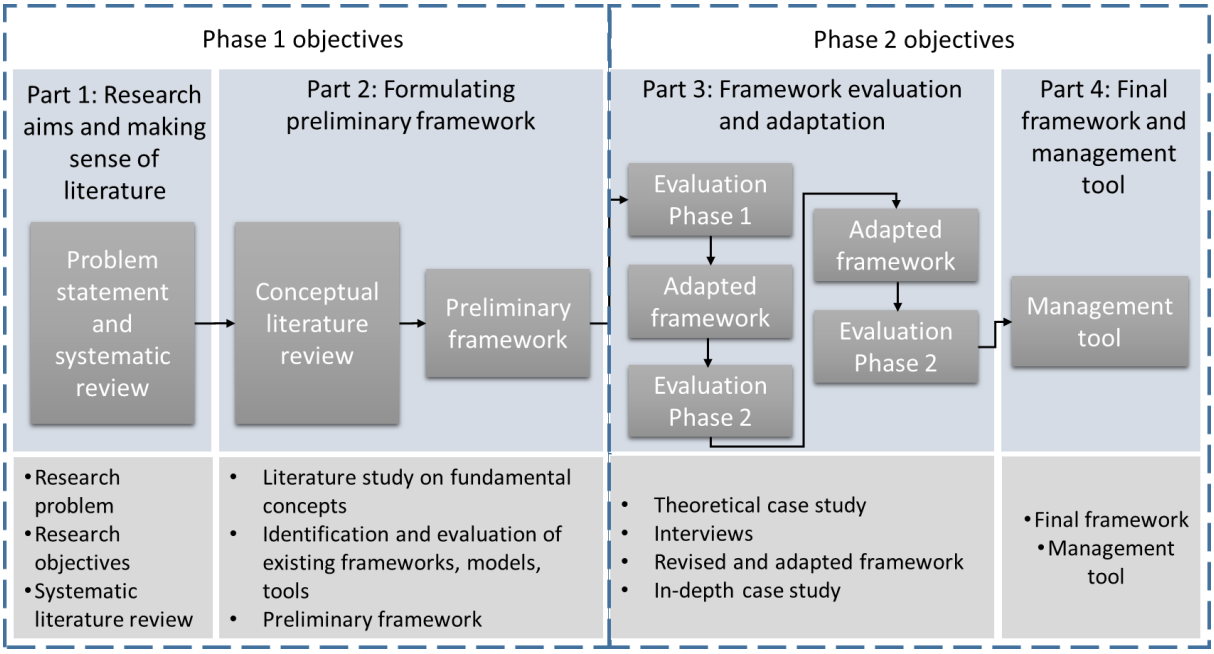


Figure 5: Research approach of this study

1.7 Aim and importance of research

The aim of this research project is to develop a framework for the design, management and implementation of technology platforms in the South African health context. Platforms have the potential to provide innovative solutions to health-related issues and increased platform adoption could result in increased health solutions. This project therefore aligns with Sustainable Development Goals 3 and 9, by encouraging the utilisation of innovative technologies to assist in increasing health and well-being. The framework could contribute towards the adoption of health platforms in the South African context.

The framework also contributes towards technology platform research and is developed to assist platform owners in overcoming the typical challenges they may face. The framework also aims to draw from both typical views on platforms, namely the engineering and economic views. By drawing from both these views, the framework aims to be generalised and useful to different types of platforms. There are also no such frameworks for the SA health context known to the researcher. The overall research contribution will be discussed in Section 10.4.

Although the research problem motivates for the increased uptake of technology platforms, the researcher took a holistic approach in developing the framework. This refers to not only considering the technology platform in the framework development process, but also the platform firm and how

it will operate and be managed. The reason behind this approach is that the technology platform itself cannot fulfil its purpose without the platform owner and platform firm supporting it, specifically relating to the control mechanisms and support structures required to manage the wider platform ecosystem. The framework was also developed from an ecosystem perspective and therefore considers the platform owner, developers and end users throughout the development process. The characteristics and needs of the ecosystem actors were incorporated into the framework and these are therefore also a contribution to platform literature.

1.8 Ethical implications of the study

The evaluation phase of this project required ethical clearance from the Research and Ethics Committee (REC) of the University of Stellenbosch. The nature of the evaluation comprised interviews which involved human opinions and data from external parties. The researcher was unaware of any risks or discomforts that were caused and tried their best to create an atmosphere that was conducive to learning. The participants were not threatened by any physical or psychological risks during the interviews. The ethical clearance for this study was granted by the REC under SU project number 1415 and the researcher took note of the following:

1. The participation in this study was completely voluntary and any participant was free to withdraw at any time.
2. The researcher was responsible for obtaining consent from participants before data collection.
3. The participants were not forced to answer any questions they did not feel comfortable with.
4. All information disclosed during the study will remain confidential and is stored in a secure location.
5. No personal information of any participant will be disclosed.

1.9 Document outline

This document comprises ten chapters. At the commencement of each chapter, a summary diagram as Illustrated in Figure 6 will be presented. The aim of this diagram is to give the context of that specific chapter with relation to two aspects: (1) the Research Design and methodology (CFA eight phases) and (2) the overarching Parts of the project (Parts 1-4). Both of these components will be discussed in detail in Chapter 2. The Research Design and methodology are indicated by the top flow diagram. The progression of the project in terms of its four Parts is indicated on the left hand side of the diagram. The relevant chapter will be highlighted with bold text. A summary of each chapter is given next.

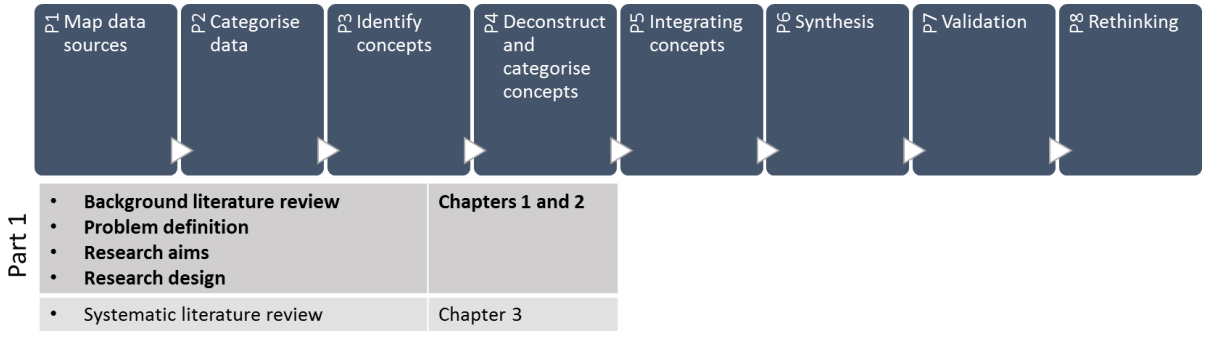


Figure 6: Example of context diagram to be included in remainder of document

Chapter 1: Introduction

The introductory chapter introduces the context of the project and gives an overview of the main concepts including technology platforms and their application within South African health. This chapter provides the motivation for the study which leads to the problem identification and research questions. The project objectives are discussed and an overview of the project given.

Chapter 2: Research design and methodology

Chapter 2 comprises the Research Design and methodology that will be followed in order to meet the project objectives. The Grounded Theory inspired conceptual framework development process by Jabareen [39] is described and related to its interpretation within this project. The steps followed to conduct a systematic literature review as well as evaluation methods are discussed in detail.

Chapter 3: Systematic literature review

This chapter presents the systematic literature review focusing on technology platforms within innovation ecosystems. The review forms the basis of fundamental concepts that feed into the chapters that follow. The results of the review include technology platform key concepts, the multidisciplinary nature of these platforms and the typical actors in a platform ecosystem.

Chapter 4: Conceptual literature review

The conceptual literature review comprises an in-depth review on technology platforms, how they relate to ecosystems and how they can be used in South African health. The context of managing a platform within a dynamic ecosystem compounded with trade-off decisions is also described. This chapter also includes the investigation and analysis of existing frameworks, models and tools that relate to this research.

Chapter 5: Framework evolution part 1: Inventory framework

Chapter 5 presents the preliminary framework, also referred to as the inventory framework, which is the first step in the framework evolution process. The inventory framework comprises three levels of concepts that were derived from the systematic literature review in Chapter 3 and the conceptual literature review in Chapter 4. The three levels are for each of the ecosystem actors as identified in the systematic literature review, namely the platform owner, developer and end users. The inventory framework formed the foundation of the final framework and management tool.

Chapter 6: Framework evolution part 1: Preliminary framework evaluation

The first evaluation part of the framework is included in Chapter 6. The MomConnect health initiative and platform was investigated and linked to the inventory framework. This yielded insights into the functioning of a successful platform specifically in the South African health context. The inventory framework was subsequently modified and adapted.

Chapter 7: Framework evolution part 1: Evaluated and adapted framework

Semi-structured interviews with platform owners, developers and industry experts formed the second framework evaluation part. The researcher engaged with nine diverse interviewees from both the international and local context. The interview data was analysed and used to modify and adapt the framework. This was done by implementing three coding cycles, each with its own outcomes.

Chapter 8: Framework evolution part 1: Towards a final management tool

The final framework evaluation part comprised a case study on Mezzanine Ware and was included in Chapter 8. The researcher aimed to gather background information on Mezzanine Ware and investigate their past and current processes and operations in order to link this information back to the framework. The insights into Mezzanine Ware resulted in yet another modified and adapted framework as well as establishing the usefulness of the framework as a tool for platform owners.

Chapter 9: Final framework and management tool

Chapter 9 presents an overview of the aim, objectives and purpose of the tool. This includes a discussion and presentation of the final tool for platform design, development and implementation in the South African context. A specific focus on the South African health context is included in this chapter.

Chapter 10: Conclusions and future work

The concluding chapter gives a concise summary of the Research Design of this study. The project objectives and the chapters which address each objective are then indicated. The contribution of the research is discussed and the limitations of the study listed. The chapter concludes with recommendations and future avenues to pursue.

1.10 Chapter 1: Conclusion

Chapter one gives the background and overview of this project. The research problem and motivation as well as the research questions and objectives are included in this chapter. An overview of the Research Design is given, followed by the main contributions of this project. The ethical implications are given and the chapter concludes with an overview of each of the document chapters. The Research Design will be presented in the next chapter.

Chapter 2: Research design and methodology

Chapter 2 key objectives:

- Provide an overview of relevant research approaches
- Explain and differentiate between qualitative, quantitative and mixed methods
- Introduce Grounded Theory methodology
- Introduce the Conceptual Framework Analysis (CFA) process
- Briefly describe the systematic literature review process
- Describe the evaluation process and triangulation
- Present the Research Design for this project
- Discuss how the South African health context will be integrated into the framework

2.1 Introduction

Chapter 2 focuses on providing an overview of different research approaches considered for the project's Research Design. The Research Design, discussed in Section 2.9, describes the methodology and processes selected to allow for the project objectives to be met. The research for this project is qualitative in nature and a Grounded Theory (GT) methodology was followed to develop the framework and the subsequent management tool. Jabareen [39] proposed a qualitative method, based on GT, to facilitate the process of developing a conceptual framework. This Conceptual Framework Analysis (CFA) approach was selected to guide the researcher in developing the framework and subsequent tool. The CFA process was used in conjunction with a systematic literature review and a progressive evaluation process to develop the final management tool. The context of Chapter 2 relating to the CFA process and within this document is shown in Figure 7.

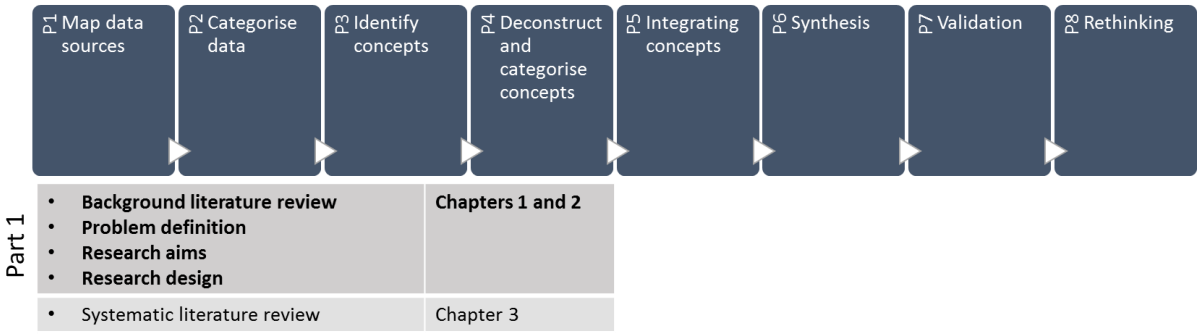


Figure 7: Document context diagram: Chapter 2

2.2 The research paradigm

When conducting research, the researcher must make a series of decisions regarding methods, methodologies and theoretical perspectives. In explaining the differences between these, James [40] adopts the metaphor of an iceberg, as illustrated in Figure 8, to conceptualise the nature of research. This metaphor emphasises the interlocked nature of ontology, epistemology, methodology and methods and distinguishes the visible, well-known parts from the hidden parts below the surface of the iceberg. In this metaphor the section above the surface refers to the research methods which are usually well described and popular. These include data collection methods such as interviews, questionnaires, observations and experimental observations and also analytical techniques such as coding, discourse analysis and statistics [40].

The first section below the surface refers to the methodology of the study [40] which relates to the research approach. The research approach includes qualitative, quantitative or mixed methods and can also refer to a case study, ethnography or the chosen experiment. The remainder of the iceberg

includes the epistemology and ontology views. The epistemology refers to the selected view of what is considered as acceptable knowledge [41]–[43]. The ontology refers to the nature of the phenomena and what is seen as reality [41]–[43]. The chosen ontological and epistemological orientations form the researcher's holistic view of knowledge [44] and flow into the choices regarding qualitative and quantitative research approaches. Figure 9 indicates the different research terms and their relationships.

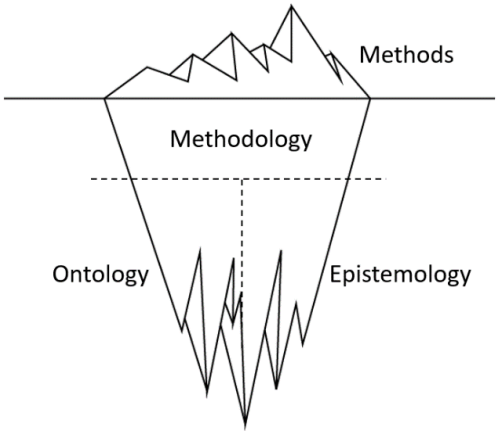


Figure 8: Research paradigm iceberg metaphor illustration

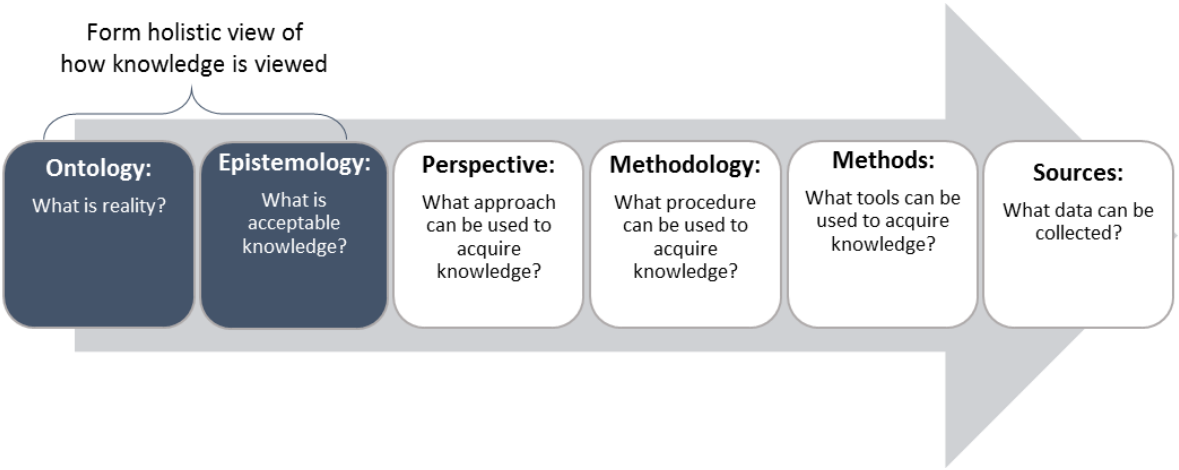


Figure 9: Terms and relationship of research (Adapted from [44])

2.3 Qualitative and Quantitative research

The relationship between theory and research can be described as being either inductive or deductive. Deductive approaches focus on theory guiding the research whereas inductive approaches focus on theory being an outcome of research [41]. Quantitative research is often deductive as it involves a theory or hypothesis to be tested and revised based on the findings [41], [45]. Inductive research refers to developing a theoretical understanding of a phenomenon based on data such as interviews and focus groups and is therefore most commonly associated with qualitative research [41]. Research can be approached in a qualitative, quantitative or mixed methods manner. Table 3 indicates areas of consideration in conducting research and their relation to quantitative and qualitative research.

Table 3: Research considerations in qualitative and quantitative approaches [41]–[43]

Area of consideration	Quantitative	Qualitative
Theory to research relation	Deductive, empirical theory testing	Inductive data leads to theory
Epistemological orientation: The adopted view of what is acceptable knowledge.	Positivism: Natural science methods	Interpretivist: respecting differences between natural

Area of consideration	Quantitative	Qualitative
		science methods (objects) and social sciences (people).
Ontological orientation: Concerned with the nature of social phenomena.	Objectivism: social phenomena are beyond ability to influence and are independent of social actors.	Constructionist: social phenomena is produced by interaction of social actors .

Qualitative research explores and aims to understand individuals, groups and the social problems they encounter [43]. It develops and refines concepts throughout the research process, involves text, writing and transcribing through analysing and collecting non-numerical data. It focuses on analysing individuals or groups, their interactions, communications and experiences and provides explanations for it [41], [42], [45]. Qualitative research approaches often constitute four important considerations as shown in Table 4. These components include choosing the appropriate research design, the data collection method, its interpretation and analysis as well as specific criteria for evaluating the qualitative research [41].

Table 4: Overview of qualitative research design and methods [41], [43]

Qualitative research design options	Data analysis and collection methods	Data analysis and interpretation	Criteria in qualitative research
Ethnography	Direct observation	Coding	Validity
Phenomenological design	Participant observation	Statistics	Trustworthiness
Grounded Theory	Qualitative interviews	Narrative analysis	Credibility
Case study	Surveys	Content analysis	Reliability
Narrative research	Focus groups		
	Case studies		

Quantitative researchers focus on measurement, causality [42], generalisation and replication due to their epistemological orientation. Measurement refers to the ability to reliably measure concepts and causality refers to thinking about both the cause and effect. Generalisation aims to generalise the findings beyond the research context and replicability refers to requiring explicit methods in order to enable other research to precisely replicate the study conditions [41]. Quantitative research investigates the relationships among variables in order to verify or test a theory [43].

Qualitative and quantitative research have differences in areas such as their purpose, approach, data collection and independence of the researcher [41], [43], [46]. These differences are shown in tabulated form in Table 5. Moreover, the differences in these approaches lie in their methods, overall strategies and philosophical assumptions [43].

Table 5: Comparison of qualitative and quantitative research approaches [41], [43], [46]

Component	Qualitative	Quantitative
Purpose	Discover ideas, in-depth understanding of phenomenon	Test hypothesis or specific research questions
Approach	Observe and interpret	Measure and test
Data collection	Unstructured Rich, thick and deep data	Structured Hard, reliable data
Researcher independence	Researcher intimately involved	Researcher uninvolved, objective results
Most often used in	Exploratory research designs	Descriptive and casual research designs
General approach	Words and description	Numbers and measurement

Mixed methods research combines qualitative and quantitative research approaches [41]. Mixed methods involves the collection of both quantitative and qualitative data. The motivation of adopting

this research methods is often the additional insight that may be obtained by combining the methods compared to each on their own [43].

Therefore, when formulating a research design, the researcher should consider the abovementioned research paradigm and subsequently decide upon his or her epistemological and ontological orientations. This will influence the choice of qualitative or quantitative research, as well as the data collection and data analysis methods. This process is illustrated in Figure 10.

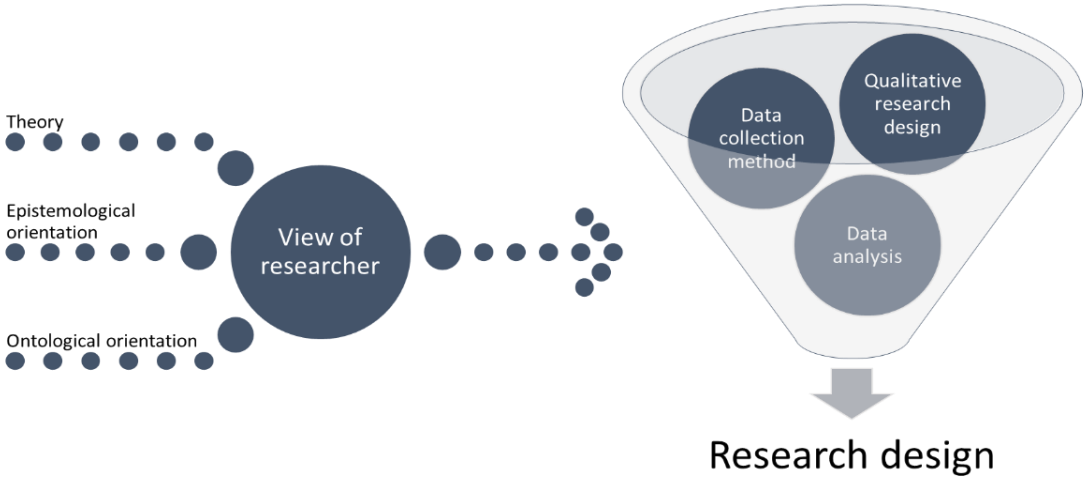


Figure 10: Towards a research design

2.4 Grounded Theory methodology

"Good qualitative research results from hard work and systematic approaches. That means gathering enough data, synthesising them and making analytic sense of them." – Kathy Charmaz

Grounded theory is often adopted by inductive researchers to obtain and analyse data and generate a theory [41]. Grounded theory was originally developed by Anselm Strauss and Barney Glaser in 1967. A split between Strauss and Glasier was followed by Strauss and Corbin's publication in 1990. More recently, in 1995, Charmaz has emerged as another seminal author in Grounded Theory [47]. Therefore GT has evolved since its origin and diverse perspectives emerged which differ in relation to induction and deduction, data coding and the generated theory [48].

Grounded Theory methods are a set of strategies for analysing data to develop *a* theory, and not *the* theory as each person's cognitive style would be reflected in their research approach [48]. Its name is derived from the research strategy by which a vast amount of data is continually compared in order to formulate a theory grounded on the data [49]. The research commences with investigating data and thereby formulate conceptual categories and synthesise, explain and identify patterns [50]. Grounded Theory allows researchers to make sense of large amounts of data and to check, refine and develop their inferences about the data [50]. GT can be adopted as the appropriate method to answer research questions for research of 'every kind' [50].

2.5 Conceptual framework development process

The conceptual framework development process by Jabareen [39] follows an inductive Grounded Theory approach which aims to "*generate, identify and trace a phenomenon's major concepts – each of which has its own attributes, characteristics, assumptions, limitations, distinct perspectives and specific function within the conceptual framework – that shed more light on the phenomenon represented by the concepts themselves*" [39, p. 53]. The advantages of this approach include its flexibility, ease of modification and the focus on understanding instead of predicting. It develops a

framework through a qualitative analysis process of a multidisciplinary nature to provide an interpretative approach to social reality [39].

A key motivation for adopting the approach outlined by Jabareen [39], is the multidisciplinary nature of the research. The different research areas involved with the technology platform's governance, management, design and general functioning include software engineering, innovation and management [51], strategy, economics, knowledge management and organisational studies literature [52]. In their systematic review aiming to identify key concepts in the technology platform literature, Herman, Grobbelaar and Pistorius [53] also discussed the diversity of literature regarding technology platforms which includes studies on innovation, social science, systems perspective and ecosystem related fields. The eight-phase procedure of the CFA process was used to develop the framework for this project and is described in Table 6.

Table 6: CFA stages and descriptions [39]

Phase	Description of Phase
Phase 1: Mapping of data sources	Map the spectrum of multidisciplinary literature regarding the topic. Starts with extensive review of multidisciplinary texts. Data collection should be comprehensive and complete. It should facilitate holistic mapping and complete data collection for validity.
Phase 2: Reading and categorising of data	Read the selected data and categorise it. Categorisation by importance scale end representative power within each discipline. This ensures effective representation of each discipline.
Phase 3: Identifying and naming concepts	Read and reread selected data to discover the concepts. Outcome of phase is a list of competing and sometimes contradictory concepts.
Phase 4: Deconstructing and categorising concepts	Deconstruct each concept. This is to identify its main attributes, characteristics, assumptions and role. Therefore concepts can be organised and categorised accordingly. The outcome of this phase is a table with four columns. The headings are: names of concepts, description of concept, categorisation of concept and references for each concept.
Phase 5: Integrating concepts	Integrate and group concepts together. This phase reduces the total number of concepts and allows manipulation to a reasonable number of concepts.
Phase 6: Synthesis and resynthesis	Synthesise concepts into a theoretical framework. It is an iterative process of synthesis and resynthesis until a general theoretical framework is recognised.
Phase 7: Validating the conceptual framework	Establish whether the framework and concepts make sense to other scholars and practitioners. Validation is sought from 'outsiders' who should give feedback.
Phase 8: Rethinking the framework	The framework environment will always be dynamic and may be revised.

Conceptual and theoretical frameworks are often used interchangeably. However, Imenda [54] argues that an inductive approach, such as Grounded Theory, leads to conceptual framework development. A conceptual framework is therefore a synthesis of relevant concepts. Theoretical frameworks are used in a deductive approach and are formulated from theories. Therefore theoretical frameworks refer to the application of a theory or part thereof [55]. Adom, Joe and Hussein [55] highlight some of the key differences between a conceptual and theoretical framework as shown in Table 7.

Table 7: Distinguishing between a theoretical and conceptual framework [55]

Theoretical framework	Conceptual framework
Based on existing theory that has been validated and tested	Based on concepts that are significant within the research
Used to test theories	Used to encourage theory development that could prove useful to practitioners
Comprises theories that seem interrelated	Comprises concepts that are interconnected and explains their relationships

Frameworks can be developed and subsequently used as tools for practical purposes [56]–[58]. The Oxford English Dictionary defines a tool as "*a thing (concrete or abstract) with which some operation is performed; an instrument".* Therefore, the aim is to develop a conceptual framework that can be used as a practical instrument or tool that platform owners can use to design, develop and implement their platforms.

The researcher identified a systematic literature review as an appropriate method of following the first four phases of the CFA process.

2.6 Systematic literature review

Systematic literature reviews aim to collect all empirical evidence that meet the predetermined criteria required to answer a specific research question. It works from a search strategy to identify, appraise and synthesise data from several studies and aim to minimise bias [59]–[61]. The result is a fair evaluation of the research area of interest through a "*trustworthy, rigorous and auditable methodology*" [61, p. vi]. The review maps out possible areas of uncertainty [62], allows for the identification of gaps for further investigation and sets a trajectory for future research [61].

Kitchenham and Charters [61] define three main stages in the systematic review process. The first stage comprises planning the review and includes the research question(s) and developing the research protocol. The second stage is conducting the review which includes identifying and selecting the primary studies and extracting, monitoring and synthesising the data from the primary studies. The final stage includes reporting the review and its results.

The main purpose of the systematic review conducted in this study was to identify the key concepts of technology platforms within their ecosystems. The systematic literature review nexus for this study is illustrated in Figure 11.

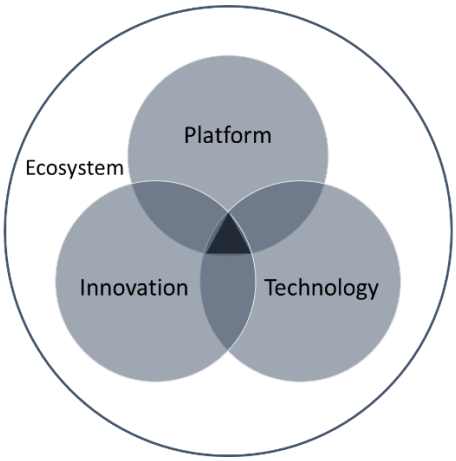


Figure 11: Systematic review focus areas and nexus point

The systematic literature review was conducted in accordance with the first four stages of the CFA process. The subsequent stages include the formulation of the preliminary conceptual framework. Phases 7 and 8 include the iterative process of evaluating and rethinking the framework.

2.7 Validation

The concepts of validity and reliability are traditionally associated with quantitative research [42]. Creswell [43] specifies that qualitative validity refers to the accuracy of the findings and qualitative reliability refers to the consistency of the research across different researchers. Golafshani [42] has also undertaken to understand these criteria in the qualitative research context. As a result, validity and reliability in qualitative research are conceptualised as "*trustworthiness, rigor and quality*" [42, p. 604] and triangulation suggested as a method to "*eliminate bias and increase truthfulness of a*

proposition" [42, p. 604]. Rhineberger and Van Valey [63] also suggest the use of triangulation as a method of improving validity and reliability in qualitative research if the different methods all verify the results.

Triangulation is a qualitative research evaluation and cross-checking method to ensure that the research findings are reliable and valid [41], [42]. Webb, Campbell, Schwartz and Sechrest [64] originally conceptualised triangulation as a way to increase confidence in the results and is based on the triangulation metaphor used in navigation [64]. The argument is that every data-gathering class including interviews, surveys and observation inherently has threats to the validity of a study. As a result, multiple methods should be used to verify the results and minimise bias and threats to validity [63]. Data analysis methods in qualitative research include focus groups, surveys, qualitative interviews, participant observation and direct observation [41]. Triangulation as implemented in this study is illustrated in Figure 12.

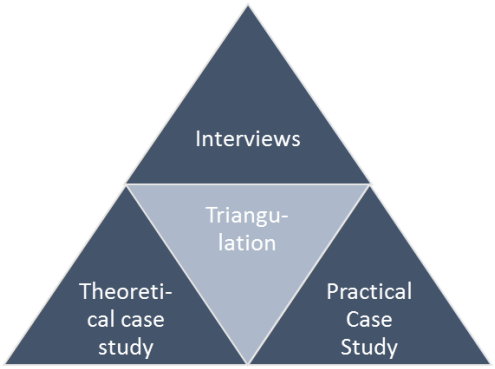


Figure 12: Evaluation: triangulation

Three of the main methods of evaluation that could be followed as a part of Phases 7 and 8 of the CFA process include a theoretical case study, semi-structured interviews and an industry-based case study. These three steps was used as a triangulation strategy in order to minimise bias and threats to validity.

2.7.1 Semi-structured interviews

Interviewing is a common and powerful way to build understanding and can be structured, semi-structured or unstructured [65], [66]. Interviews are useful when personalised data is required, probing is necessary and a good return rate is needed [67]. Unstructured interviews are open-ended, less formal, exploratory and without prior categorisation which could limit the interview data [67]. There are no restrictions on questions and topics and they are especially useful when little information is known on a topic. Disadvantages of unstructured interviews include possible bias and inappropriate questions, particularly when the researcher is inexperienced. The interview data may also be difficult to analyse [67]. Structured interviews, also called standard interviews [67], aim to gather precise data which can readily be coded and falls within pre-established categories [66]. During structured interviews the researcher has complete control over the themes covered and the interview format. Disadvantages of structured interviews include limited exploration, interviewees may misinterpret the fixed questions and the researcher's verbal and non-verbal cues could influence bias due to unintended effects on interviewees [67].

Semi-structured interviews are the third qualitative data collection approach [43]. Semi-structured interviews are more open than structured interviews and allow for new ideas to be explored based on the interviewee's responses to certain predetermined questions, themes or topics [67], [68]. As a result, the researcher can probe the interviewee to explore deeper into specific themes or topics and also explain possible unclear questions [67]. A disadvantage of semi-structured interviews is the possibility that inexperienced researchers may inadequately prompt the interviewee in order to collect relevant data [67]. The interview is usually recorded and subsequently transcribed to implement

coding strategies on the raw data. Creswell [43] suggests developing an interview protocol which includes the interview information, the standard instructions that should be followed throughout all interviews and the questions to be asked. It is also suggested that the recording of the interview should be paired with handwritten notes in case the recording might not be available for use. The interview should also be conducted with complete transparency on possible ethical implications [67].

Semi-structured interviews are useful when the interviewees are not available for several follow-up interviews [69]. While more open-ended, the interview protocol or guide allows for reliable and comparable data. Semi-structured interviews provide the balance between inclusions of mandatory topics as well as providing the environment for new perspectives and understandings of a certain topic [69]. These interviews also allow the researcher to prepare and generate further probing questions ahead of time. Consequently, for the purpose of this study, semi-structured interviews were conducted as a part of the CFA process. Rabionet [68] developed a six-stage process for conducting semi-structured interviews. The steps and outcomes are explained in Table 8. The stages include selecting the interview type and establishing the ethical considerations followed by setting up the interview protocol. The protocol is followed by conducting and analysing the interviews and the final stage involves reporting the findings.

Table 8: Interview guidelines [68]

Stage	Stage description
1. Select interview type	Choose between structured, semi-structured and unstructured interviews
2. Establish ethical guidelines	Investigate possible consequences, consent, confidentiality and protection issues regarding the interview
3. Craft interview protocol	Gather information regarding context and develop questions and follow-up probes
4. Conduct interviews	Conduct and record the interviews
5. Analyse the interviews	Data analysis
6. Report the findings	Presenting the results of the interview data

Another method to validate the research is by means of a case study. An overview of the case study approach is discussed next.

2.7.2 Case study

A case study aims to investigate the 'why' or 'how' of a phenomenon and can be exploratory, explanatory of descriptive [70], [71]. By implementing a case study, a complex phenomenon can be investigated within its natural context by obtaining data from a variety of sources [72]. The use of multiple data sources leads to the researcher taking on different lenses to better understand the phenomenon. Yin [70] and Stake [73] are seminal authors of case study research who based their approaches on the constructivist paradigm. Subsequently, case study research typically includes close collaboration with participants and an interest in their stories, opinions and views of reality [72]. This is an advantage of the case study approach and allows for in-depth understanding of the phenomenon through adopting diverse lenses.

Tellis [74] proposed a four-step process for conducting case studies as shown in Table 9. The first step requires the researcher to design the case study protocol, which typically comprises an overview of the context of the case study, the field procedures required to conduct the desired case study, the case study questions and the case study report [71]. As suggested by both Yin [70] and Stake [73], clear case study boundaries are vital to prevent the case study from becoming too large thereby compromising its ability to meet its initial goals. Therefore, care needs to be taken to refrain from answering too many objectives with the case study. Following the case study protocol, the case study is conducted, data analysed and subsequent conclusions, recommendations and implications

presented. Some criticisms of the case study approach include the lack of systematic data handling, that there is no basis for scientific generalisation and that it is time-consuming [70]. The researcher should therefore aim to maintain systematic reporting of all data and set clear time limits.

Table 9: Guidelines for the case study process [74]

Case study step	Description
1. Design the case study protocol	Determine the required skills, develop the protocol, review the protocol
2. Conduct the case study	Prepare data for collection, conduct interviews
3. Analyse the case study evidence	Develop analytic strategy
4. Develop conclusions, recommendations and implications	

A key component of both semi-structured interviews and case studies is data analysis. The way in which the data analysis is completed will either lead to greater insights into the topics, or the researcher will miss out on the richness of the data.

2.8 Data analysis

Following the qualitative data collection methods as described above, Creswell [43] suggests a six-step process for qualitative data analysis, shown in Figure 13. Although presented in a linear manner, some steps are interrelated and may not be implemented in the exact order illustrated. The first step includes organising and preparing the data which include transcribing and arranging the data into a usable format. The second step involves reading through all the data in order to get a general sense of the themes and concepts. This step may include formulating overall impressions of depth and credibility and inferences as to the overall meaning of the data. The third step includes the coding of the data. Coding refers to the process of categorising, labelling or organising of the data by allocating specific terms to the data categories. Some coding types include setting and context codes, different perspectives undertaken, process, activity, strategy and relationship codes [75].

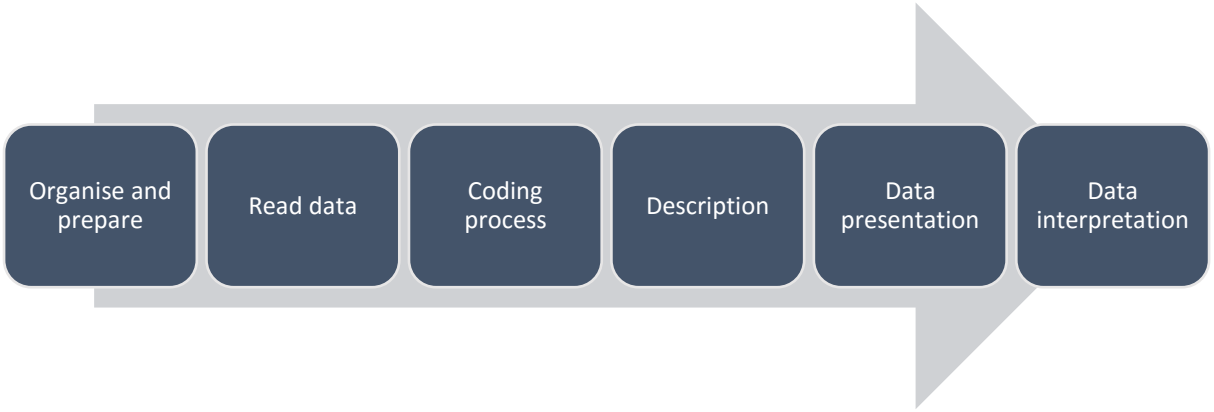


Figure 13: Data analysis process in Qualitative research [43]

The fourth step suggests using the coding process to generate a description of the setting, categories or themes within the data. These themes can be used for additional analysis layers and to identify more complex theme connections. Step five of the process requires the researcher to decide upon the manner in which the results will be represented. Some approaches include a chronological discussion, a discussion of themes, or a discussion of some of the interconnected themes. Researchers can also present tables, figures or drawings to convey information. The sixth and final step of the data analysis process refers to the interpretation of the data. This step aims to clarify the lessons learnt from the research and highlights new questions for future research.

Taking the qualitative research methods, data collection and data analysis into consideration, the researcher formulated a Research Design which will allow for the project objectives to be met.

2.9 Research design

The Research Design is informed by the chosen worldviews and includes the detailed methods of data collection and analysis [43] that will best enable the study objectives to be met. The research conducted in this study is qualitative in nature and the methodology chosen is the GT-based CFA process by Jabareen [39]. The eight phases of the CFA process were adapted for this project and divided into four overarching Parts as shown in Figure 14. Figure 14 also indicates the building blocks (white stacked blocks) for each of the four Parts respectively. Part 1 comprises the elements required to make sense of the literature and to identify the research aims and objectives. Part 2 includes an in-depth literature study and investigation of existing frameworks, models and tools (FMTs) in order to formulate the inventory framework. Part 3 of the study includes the evaluation of the framework. The final Part of the study presents and discusses the final framework and management tool. The four Parts will be discussed in more detail next.

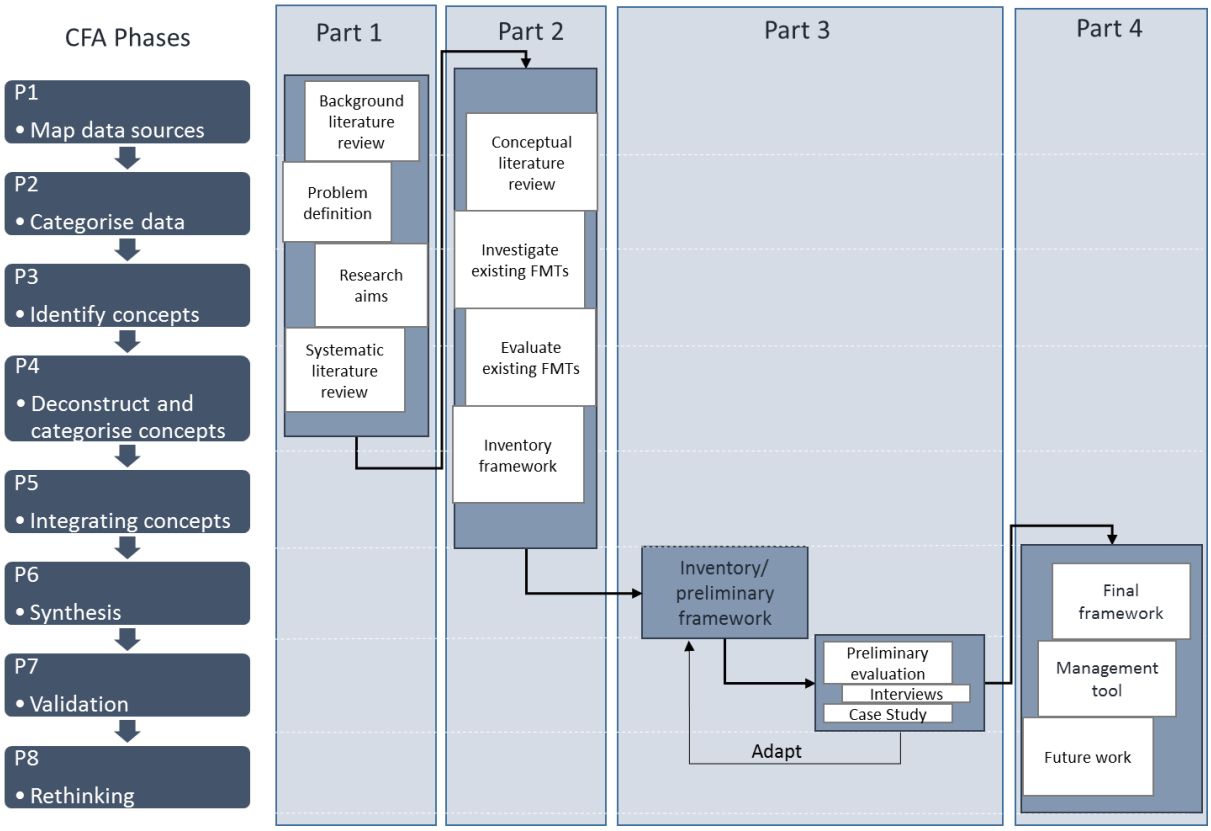


Figure 14: Research Design overview: CFA, Parts 1 – 4 and their respective building blocks

2.9.1 Part 1: Research aims and making sense of the literature

The first Part of the project focuses on establishing an understanding of the research landscape and the required literature. Therefore, Part 1 comprises defining the problem and research aims, an overview of relevant literature and a systematic literature review. The systematic literature review had three aims and was guided by the approach developed by Kitchenham and Charters [61] and Petticrew and Roberts [76]. The first aim was to identify the key concepts of technology platforms and the ecosystems in which they operate. The second was to establish the actors within the platform ecosystem and obtain an overview of their roles. The third and final aim was to determine the different research areas involved in this specific area of focus. These results formed the foundation for the rest of the study. A summary of the components is shown in Figure 15.

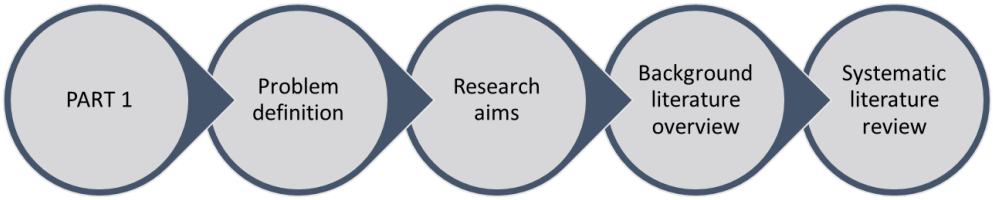


Figure 15: Overview of Part 1 of the Research Design

2.9.2 Part 2: Formulating the preliminary framework

Part 2 of the project focused on using the knowledge gained from Part 1 to further investigate literature and to develop a preliminary framework. This built directly upon the outcomes of Part 1 to direct the in-depth and focused conceptual literature review. A large section of Part 2 comprised the investigation of current models, frameworks and tools related to managing technology platforms and their ecosystems. These were evaluated, assessed and used to inspire the preliminary (inventory) framework. A summary of the Part 2 components and order in which they will be done is shown in Figure 16.

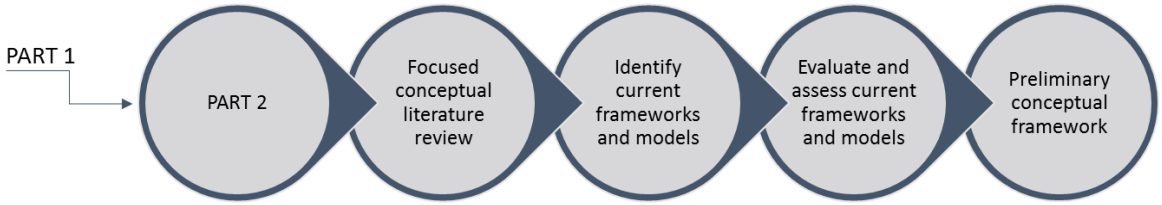


Figure 16: Overview of Part 2 of the Research Design

2.9.3 Part 3: Evaluation and adaptation of framework

Following the integration and synthesis phases, Jabareen [39] suggests the validation of the framework to establish whether it makes sense and to obtain external inputs on the framework. However, in this research the researchers followed a progressive evaluation process. The conceptual framework is broad and continuously evolving and therefore an evaluation process, rather than validation was followed. Validation would aim to prove the accuracy, whereas evaluation aimed to ensure the framework is applicable and valuable within its context of use. Therefore, Part 3 of the project comprised the evaluation of the framework. The first stage of the evaluation process was a preliminary evaluation focusing on an existing Health platform in South Africa, MomConnect, and how it relates to the framework. The second evaluation stage included local and international interviews to identify any missing concepts within the framework. In order to practically implement the framework, stage three included a case study and case study interviews which led to the formulation of the final framework and management tool. The summary of the Part 3 of this project is indicated in Figure 17.

Figure 18 indicates the context within the larger study, the evolution process of the framework and the outcomes of each evolution stage. The evolutionary nature entails the framework evolving from the initial inventory framework to the final tool as shown on the left side of the figure.

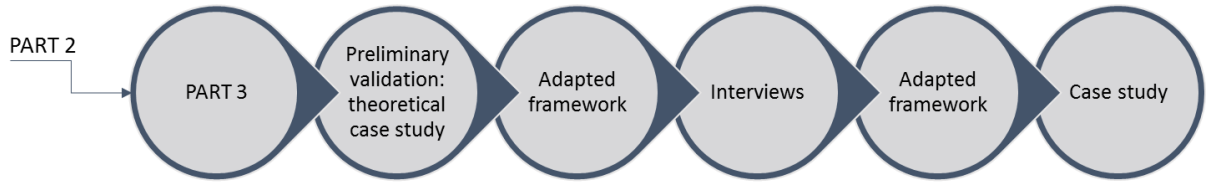


Figure 17: Overview of Part 3 of the Research Design

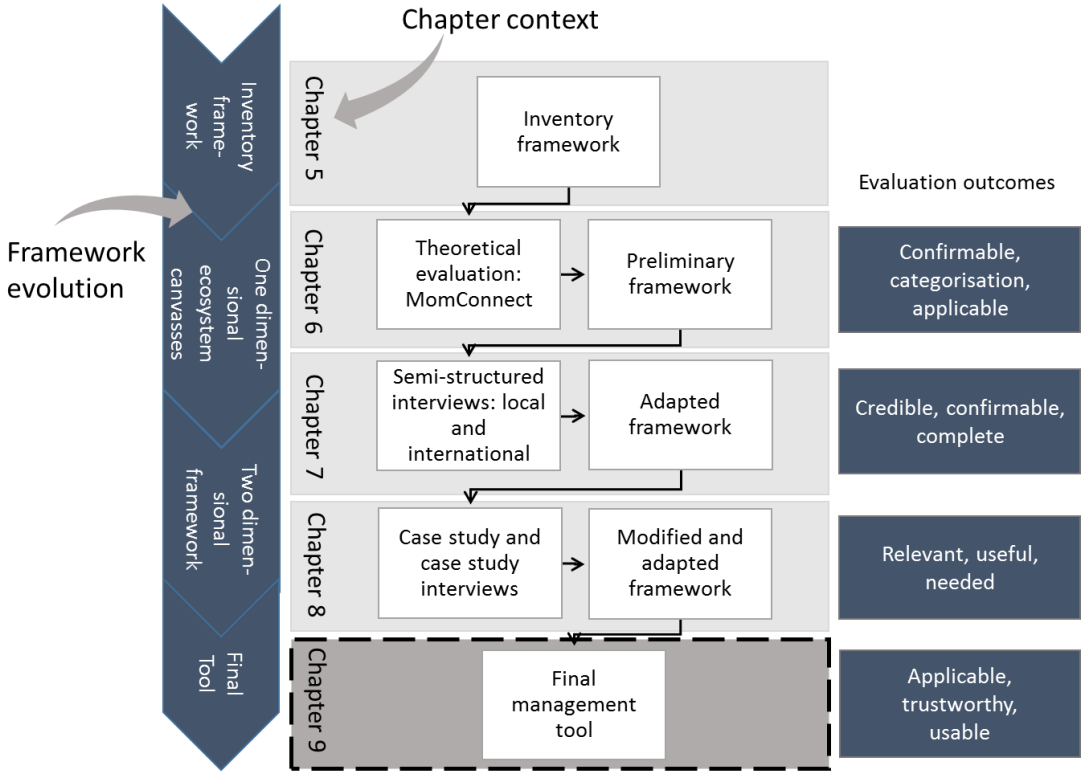


Figure 18: Progressive evaluation process, framework evolution and outcomes

2.9.3.1 Preliminary evaluation: Theoretical case study

As a result of Part 2 of the Research Design, a framework consisting of an inventory of concepts drawn from literature was constructed. This inventory framework had no practical insight and was merely concepts that were categorised and synthesised to construct the preliminary framework. Therefore, the aim of the preliminary evaluation of the framework was to investigate an existing and successful platform within the South African health context and thereby gain insight into what a framework should entail.

The inventory of concepts was applied and translated to understand how it can be related to the implementation, operation and sustainable design of an existing health platform. As a result of this application, the inventory framework was rearranged and categorised into useful and relevant categories and subcategories. The concepts were also confirmed and insight gathered into the applicability within a real-life platform.

2.9.3.2 Semi-structured interviews: Industry experts, platform owners and developers

Semi-structured interviews formed the second stage of the framework evaluation process. The semi-structured interviews were conducted with multiple firms in both the local and international arenas. The outcomes of this evaluation stage were to determine the credibility of the framework and its concepts, to confirm the current concepts and to determine whether any additional concepts and categories were missing from the framework.

The interviews were conducted with three different groups: industry experts in predetermined fields, platform owners and developers. The industry experts were selected based on the results from the systematic literature review regarding the multidisciplinary nature of the management tool. The expert fields included technology and digital innovation, health and business ecosystems. Therefore industry experts in these fields were included in the interview process to obtain insight from these diverse perspectives. No platform is the same and therefore the approach was to conduct interviews with a diverse group to get data from different perspectives. This was motivated by the approach to develop the framework to be as generalised as possible. The interview process was done according to the process outlined by Rabionet [68] as discussed in Section 2.7.1.

The data analysis was done according to the process outlined by Creswell [43]. This included implementing three coding cycles, each with different outcomes. The coding cycle approach was informed by Saldana [77]. Following the coding and subsequent analysis of the interview data, the framework was adapted and modified based on the findings.

2.9.3.3 Industry-based case study

The third step of the evaluation process was to conduct a case study on a technology platform firm and their platform in the South African health context. The case study aimed to identify the successful components of the firm and platform and subsequently learn from these insights. The case study also aimed to prove the relevance and usefulness of the tool.

The case study was conducted on a technology platform firm, Mezzanine Ware, which operates within the South African health context. The case study comprised three components: (1) obtaining and analysing background information regarding the firm, their platform and ecosystem, (2) obtaining deeper insights into the firm, their platform and ecosystem and (3) establishing the usefulness of the tool within such a context. Subsequently, various data sources were pursued. The data analysis resulted in further modifications and adaptations to the framework. Following the case study, the final framework and management tool were developed.

2.9.4 Part 4: Final framework and management tool

The final framework and management tool could be developed as a result of the progressive evaluation process shown in Figure 18. Part 4, the final part of the study therefore comprised formulating and presenting the final framework and tool. The impact and use of the tool could be discussed and linked specifically to health in South Africa. The limitations of the study, recommendations and possible future avenues for work formed the final component of the study. An overview of the Part four components is shown in Figure 19.

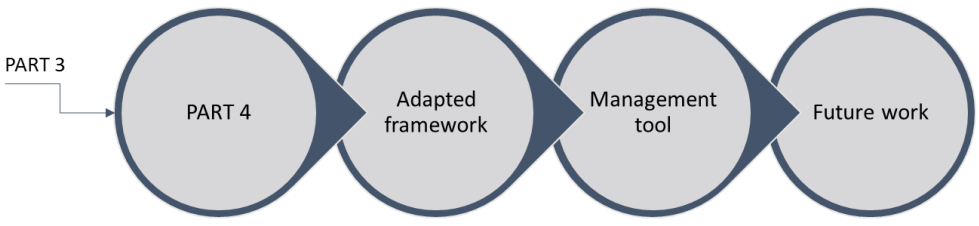


Figure 19: Overview of Part 4 of Research Design

The above-mentioned four Parts therefore formed the overarching Research Design for this project. The incorporation of the SA health context into these four Parts will be described next.

2.10 Framework for South African health context

The approach undertaken to develop the framework for use within the SA health context comprised four particular components as shown and linked to the four Research Design Parts in Figure 20. The first component included the background investigation and problem identification specifically within the SA health context, described in Chapter 1. As the starting point for the framework, the researcher subsequently investigated the technology platform and ecosystem literature for a general understanding of the literature (Chapters 3 and 4). Although this component did not have a specific focus on health, it was key for the framework foundation as the core technology, software and characteristics behind all platforms will be similar. The investigation of the South African health landscape is discussed in Section 4.6.2 as a part of the conceptual literature review. This third component allowed the researchers to gain insight into the SA health landscape prior to the evaluation process.

The final component, the evaluation process as shown in Chapters 6 to 8, accounted for the largest contribution towards the tailoring of the framework for the SA health context. All three the evaluation steps had a focus on health and the South African context. Therefore, the researcher continuously aimed to bring the platform and ecosystem literature back to the South African health context.

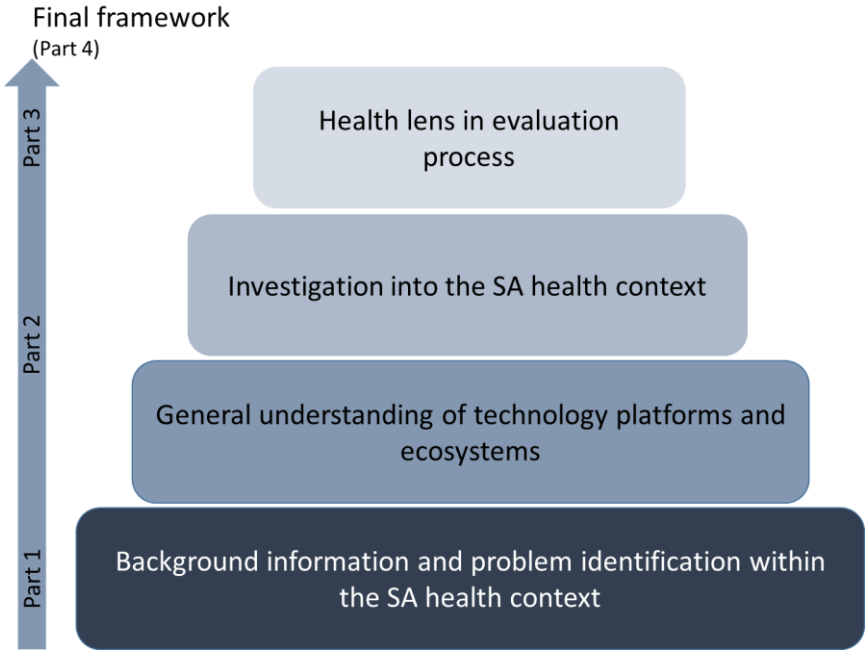


Figure 20: Incorporating the South African health context into the framework

2.11 Chapter 2 summary

This chapter focuses on the Research Design of this project and includes a background of research approaches and views including explanations of qualitative and quantitative research methods. The chosen Grounded Theory CFA process is introduced and its application within this project indicated. The main processes and methods followed within the Research Design, as well as their implementation sections within the study are shown in Table 10.

Table 10: Summary of processes followed as described in the Research Design

Component	Process or method followed	Section of implementation in this document
Development of a conceptual framework	Jabareen CFA process [39]	Followed throughout whole study

Component	Process or method followed	Section of implementation in this document
Systematic literature review approach	Kitchenham and Charters [61] and Petticrew and Roberts [76]	Chapter 3
Conceptual literature review	Parts one to four of CFA process [39]	Chapter 4
Interview process	Rabionet [68]	Chapter 7 and Chapter 8
Data analysis process	Creswell [43]	Chapter 7 and Chapter 8
Coding process	Three coding cycles as proposed by Saldana [77]	Chapter 7
Case study process	Tellis [74]	Chapter 8
Evaluation of framework	Progressive evaluation process	Chapters 6 to 9

The project is divided into four Parts, each corresponding to specific phases of the CFA process as shown in Figure 14. Table 11 indicates the outcomes of each of these four project Parts, their relation to the project objectives and relevant chapters. The following chapter includes the systematic literature review.

Table 11: Project Parts' outcomes related to objectives and chapters

Part of study	Outcomes of part	Correspond with RO	Relevant chapter(s)
Part 1	○ Define problem ○ Establish research aims and objectives ○ Conduct background literature review ○ Conduct systematic literature review	RO1	Chapter 1 Chapter 2 Chapter 3
Part 2	○ Conduct in-depth conceptual literature review ○ Identify current models, frameworks and tools ○ Evaluate current models, frameworks and tools ○ Conceptualise preliminary framework	RO2 RO3 RO4	Chapter 4 Chapter 5
Part 3	○ Conduct preliminary theoretical evaluation ○ Conduct interviews ○ Adapt framework accordingly at each stage ○ Engage in an industry-based case study	RO5 RO6 RO7	Chapter 6 Chapter 7 Chapter 8
Part 4	○ Final adaptations to framework ○ Final management tool ○ Conclusion, future work and recommendations	RO8	Chapter 9 Chapter 10

Chapter 3: Systematic literature review

Chapter 3 key objectives:

- Give an overview of the systematic literature review purpose and steps
- Present advantages and disadvantages of systematic literature reviews
- Relate the systematic literature review to the overarching Research Design
- Discuss the planning and collection of data for the review
- Present descriptive results of the review
- Present conceptual results of the review
- Discuss how the descriptive and conceptual results relate to future research

3.1 Introduction

This chapter presents and discusses the systematic literature review conducted as a part of the first four phases of the CFA process and Part 1 of the larger project as shown in Figure 21. Firstly a background on systematic literature reviews is given, followed by a description of the steps followed to conduct the review. Subsequent to this description, the implementation of the steps and guidelines are presented. Thereafter, the descriptive and conceptual results of the systematic literature review are presented. The chapter concludes with the limitations of the systematic literature review. The content of this chapter formed part of the article that was accepted by and presented at the South African Institute of Industrial Engineering (SAIIE) 28th annual conference [53].

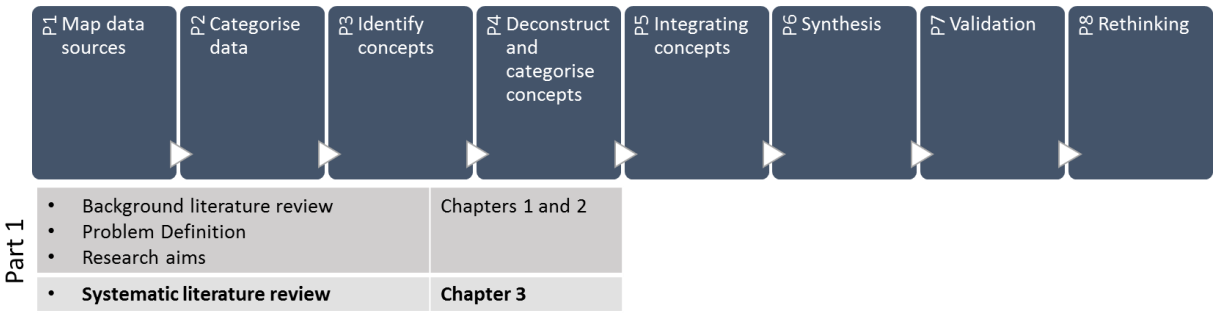


Figure 21: Document context diagram: Chapter 3

3.2 Background on systematic literature reviews

Systematic reviews are not the same as traditional narrative reviews and were originally employed to support evidence-based medicine [61]. Traditional narrative reviews, although informative, can often include bias. The reason for this is their focus on a specific area of study chosen by the author based on selection or availability [59]. Systematic reviews aim to collect all empirical evidence that meets the predetermined criteria required to answer a specific research question. It works from a search strategy to identify, appraise and synthesise data from several studies and aims to minimise bias [59]–[61]. It often includes a meta-analysis which uses statistical methods to synthesise the data from the eligible studies [62]. Systematic reviews allow researchers to delve into previous research in a specific area and thereby realises the statement by Newton: "*if I have seen a little farther than others, it is because I have stood on the shoulders of giants*" [61, p. 3].

In order to understand the need for a systematic literature review, the case for such a review is presented in Section 3.2.1. The background section concludes with a description of the steps followed when conducting a systematic literature review.

3.2.1 The case for a systematic literature review

In the literature there are several guidelines of when to conduct a systematic review. A systematic review should be conducted to: (1) develop an overall picture of the evidence in a specific area in order to direct future research [76], (2) obtain a precise idea of what research has been done, including the research methodology, which is required in the development of a new methodology, (3) identify gaps in research and (4) provide a framework to assist in positioning new research activities [61]. Kitchenham and Charters [61] emphasise the importance of ensuring the transparency and replicability of a systematic review. Therefore the review process must be thoroughly and attentively documented in order for replication to be possible. Disadvantages of systematic literature reviews include the significant amount of time and effort they take compared to traditional literature reviews, as well as the possibility of researcher bias throughout the review [61].

"It is important not only that we know what we know, but that we know what we do not know"
- Lao-Tze, Chinese Philosopher

The overarching aim of this systematic literature review was to inform the researcher regarding the research landscape. The landscape was unfamiliar to the researcher and the systematic literature review was identified as the method to explore what has been done in the specific research focus area. It was also used to direct the way forward in order to answer the research question and meet the project objectives. The aims therefore included identifying the key concepts of technology platforms in innovation ecosystems, illuminating definitions and characteristics that the researcher should be aware of, highlight the multidisciplinary nature and to form the foundation for future research.

3.2.2 Procedure in conducting the review

The *Cochrane Handbook for Systematic Reviews of Interventions* [60] identifies five key characteristics of a systematic review. Although the authors focus more on research in evidence-based medicine, these characteristics are unbiased and include a clear set of objectives and predefined eligibility criteria and the implementation of an explicit, reproducible methodology. The search should attempt to identify as many studies as possible that would possibly meet the predetermined eligibility criteria. It should include an assessment of the validity of the findings and a systematic presentation and synthesis of the findings and characteristics of the included studies.

An approach that explains the review process could be obtained from *Systematic Reviews in the Social Sciences: A Practical Guide* [62]. Their suggested review process comprises twelve steps to ensure a thoroughly conducted and successful systematic review. The steps are illustrated in Figure 22.

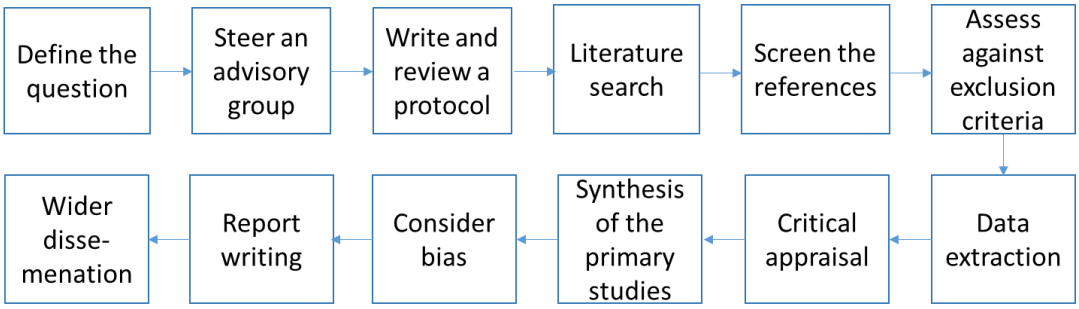


Figure 22: Proposed steps in a systematic literature review [62]

The guidelines followed for this systematic review comprised a combination of literature sources. Firstly, the requirements of the CFA process outlined by Jabareen [39] and shown in the first column of Table 12 are followed as a part of the wider Research Design discussed in Chapter 2. Secondly, the systematic review process suggested by Petticrew and Roberts [76] and Kitchenham and Charters [61] were incorporated. Table 12 gives a summary of the process which emerged from the combination

and adaptation of these sources and were subsequently followed for undertaking this systematic review. A detailed description of each phase follows below.

Table 12: Systematic literature review guidelines and link to Research Design

Stage in framework development context adapted from Jabareen [39]	Applicable section(s)	Systematic review guidelines adapted from Petticrew and Roberts [76] and Kitchenham and Charters [61].
Phase 1: Planning the review	Section 3.3	○ Substantiate gap in literature ○ Gather an advisory group ○ Write and review a protocol including review question(s), methodology, data synthesis method and criteria
Phase 2: Mapping of data sources	Section 3.4	○ Literature search/ identification of research from database. ○ Documentation of search process
Phase 3: Reading and categorising of data	Section 3.4	○ Screening of references ○ Assess against predetermined criteria ○ Document process of identifying primary studies ○ Critical appraisal
Phase 4: Identifying, naming, deconstructing and categorising of concepts	Section 3.5 Section 3.6	○ Data extraction ○ Read and rereading of studies ○ Synthesis of primary studies ○ Identifying characteristics and categorisation

3.3 Planning the review

The first step in the review process was to thoroughly plan the review. This included substantiating the gap in the literature, defining the questions to be answered by the systematic review, identifying an advisory group and writing a protocol for the review. The gap in the literature of this study was identified in Chapter 1. The systematic review aimed to provide the first building block of the conceptual framework development process. This included a review of emerging trends and the principles of evolution or life stages of a technology platform from an innovation ecosystem perspective.

The next necessary element in the review planning was writing up the protocol. This included the review question(s), methodology, how the studies are to be identified, the appraisal of the studies and how they will be synthesised [76]. It also included the study selection criteria and procedures, data extraction and synthesis strategy and the dissemination strategy of the review. The selection criteria were included in the protocol to reduce possible bias [61]. The Cochrane Handbook for Systematic Reviews of Interventions by Higgins and Green [60] suggests the PICO (Participants, Interventions, Comparisons and Outcomes) criteria for the formation of the questions. For qualitative studies, this could be altered to PICo (Problem or Population, Interest and Context) [78]. This systematic review aimed to answer the following questions:

- What are key concepts relating to technology platforms in innovation ecosystems?
- What are the definitions and characteristics of technology platforms?
- What are the multidisciplinary approaches to viewing and analysing technology platforms and innovation ecosystems?

In order to obtain the studies, the research database Scopus was used to implement the search terms guided by the research questions. The results of the final search were exported into MS Excel where they were synthesised according to predetermined criteria. The MS Excel document was adapted to allow for the coding of the predetermined categories as defined in the research protocol. These new categories included the research approaches, the research methodology (empirical, literature review),

the key concepts, citation numbers, geographic application of the study and what framework or theory was used.

The inclusion and exclusion criteria were based on the review questions as suggested by Kitchenham and Charters [61]. The criteria were classified into two categories namely C1 and C2 to distinguish which criteria would be applied at what stage of the process of primary study identification. The criteria can be seen in Table 13.

Table 13: Systematic literature review criteria

Criteria category	Criteria	Description
C1	Type of paper	Excluding conference reviews, panel discussions and lecture notes.
C1	Language	English only and language quality.
C1	Irrelevant studies	Studies focusing on aspects not related to the research questions. For example the title of an article could serve as first criteria and articles referring to innovation platforms, IoT, cloud computing and marine biotechnology, etc. were excluded.
C2	Empirical soundness	Methodology used to conduct the study and its validity. For studies using case studies, incorporating questionnaires and interviews, the number of questionnaires, response rates and interviewees were considered.
C2	Academic rigour of paper	The article should be referenced properly and clear theoretical concepts used. It should follow a proper methodology and state thorough conclusions. The length of the paper was also considered. (Critical appraisal.)

3.4 Data collection

The main objective of this phase was to map all literature sources on the chosen topic [39], as indicated in Figure 23. The final primary studies were to focus on technology platforms within innovation ecosystems, as discussed in Chapter 1. The data collection phase included the identification of literature in the Scopus research database and the initial screening of the results to reduce the number of results to a reasonable amount. For digital libraries, Kitchenham and Charters [61] suggest including the name of the database, the search strategy, the date of search and the years covered by the search as part of the complete search process documentation shown in Table 14, on the next page.

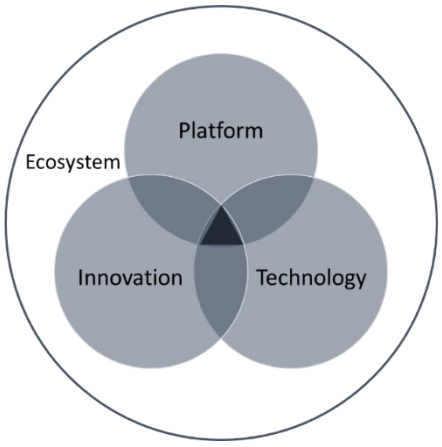


Figure 23: Systematic literature review focus area

The search strategy was based on search terms in order of descending relation to the research questions up to the point where the number of papers was an acceptable amount. By searching for the term 'Platform', the search yielded 483 301 results which was reduced to 97 620 after adding 'Technology'. This was still a considerable number of papers and the term 'Innovation' was added,

reducing the results to 4 388. As the authors decided on an ecosystem approach, the term 'ecosystem' was added, resulting in a final number of 173 results.

Table 14: Systematic literature review search results

Name of Database	Scopus	
Search strategy	Search Terms:	Results (nr):
	Platform	483 301
	Platform AND Technology	97 620
	Platform AND Technology AND Innovation	4 388
	Platform AND Technology AND Innovation AND Ecosystem	173
Date of search	30 May 2017	
Years covered by search	No limitation on publication year	

The next phase included choosing the final data sources to be used in the systematic review by assessing the above search results against the inclusion criteria where after it was read and reread in order to characterise the data [39]. The first step was the application of basic inclusion and exclusion criteria to the identified data sources. The data sources were limited to exclusively English, leaving 166 search results. Thereafter the remaining studies were exported from Scopus into MS Excel for further screening and eventual categorisation. The exported data included: (1) author(s) names, (2) paper title, (3) year of publication, (4) source title (publication/journal), (5) Affiliations, (6) abstract, (7) author keywords and (8) document type.

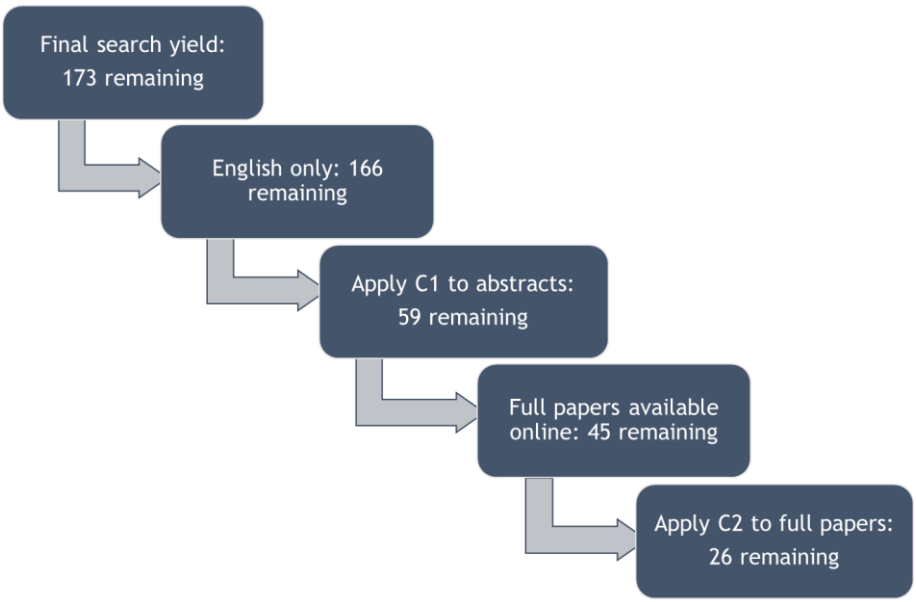


Figure 24: Process of identifying primary studies in systematic literature review

The process of identifying the primary papers is illustrated in Figure 24. As suggested by Petticrew and Roberts [76], the abstracts of the papers were screened and their relevance to the study determined where after the full papers were read and assessed against the original criteria. After applying the category 1 (C1) criteria to the abstracts of the studies and eliminating evident non-relevant studies, all conference reviews and panel discussions amongst other criteria, a total of 59 papers remained. The online availability of these papers was checked and only 45 could be obtained in full text. Books were also excluded as full versions could not be found. Next, the full papers were screened and assessed against the first category (C1) and the second category of criteria (C2). This resulted in the final number of 26 papers which are included in Appendix A. After the initial screening of the abstracts and paper content, the data sources were thoroughly read to allow for an overview of data categories.

The next phase included the re-reading of the primary studies, extracting the data and identifying and categorising the main identified concepts. Extracting the data is a systematic approach where all relevant information is extracted from the primary studies [76]. This process should focus on extracting the data relevant to addressing the review questions [61]. Through the detailed reading of the final papers, each was critically appraised with respect to its methodological soundness. This aided with any biases and to help the author interpret the data as suggested by Petticrew and Roberts [76]. This phase also included the synthesis of the data by systematically describing, reporting, tabulating, and integrating the results of the studies, which resulted in the deconstruction of each identified concept described by Jabareen [39]. The deconstruction included identifying the characteristics and assumptions and organising and categorising it according to aspects such as methodology and the empirical methods used. The results of further reading and categorisation are presented in Section 3.5.

3.5 Descriptive data analysis

As a result of the exported data from the primary studies of the systematic review, certain descriptive data could be obtained through coding and analysis of the data in MS Excel. This data was interpreted for deeper insights into the research. Figure 25 indicates the number of citations for the author(s) of each paper where the citation numbers were obtained from Google Scholar on 8 June 2017. This figure aided in identifying the seminal authors in the discovered research fields. This graph made the researcher attentive to the most cited authors after which their names were recognised in numerous other papers. These authors were thus noted in the further continuation of the project.

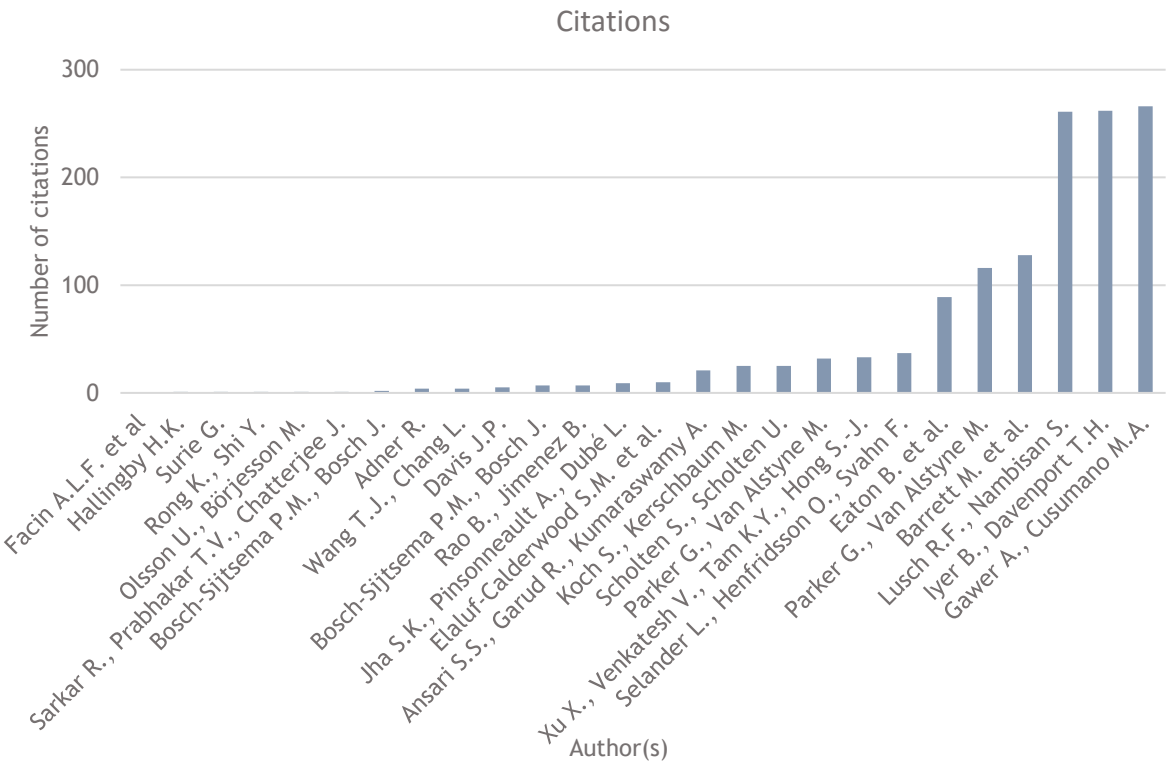


Figure 25: Primary studies' citation rankings

In conjunction with the citation rankings of the papers, the timeline of the publication dates was also noted and is shown in Figure 26. The timeline indicated that the first study was published in 2007. Therefore, even though technology platforms might seem like a recent concept, the researcher should not only focus on studies that are recently published, but also look at older publications for a more comprehensive picture of literature regarding technology platforms and their ecosystems.

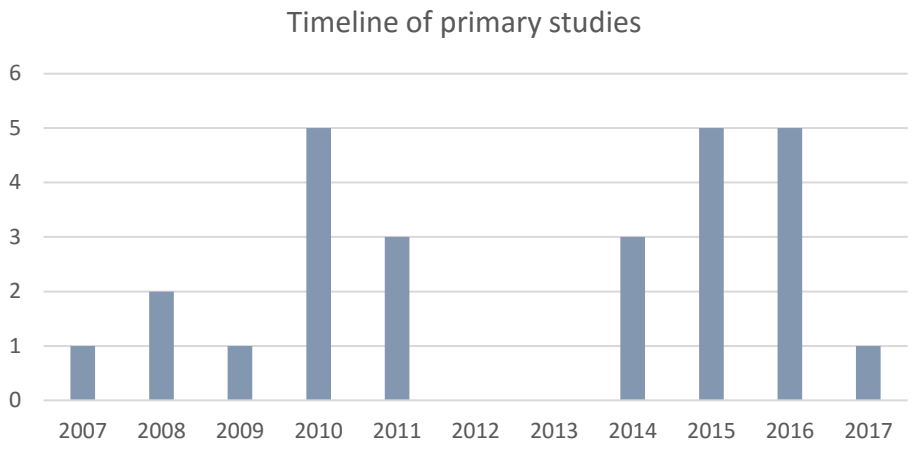


Figure 26: Timeline of primary studies

The methodologies used in the papers in terms of a literature review, theory or empirical method such as a case study were also examined. By analysing the primary studies, it could be determined that 77 percent of the studies were case studies and the remainder of the studies derived models or conducted literature reviews. The case study papers were examined further to determine the geographical application area of the case study. In Figure 27, the term 'Global' refers to the application of the case study in a firm that has global 'footprint' such as Apple, Microsoft or Intel and as a result was not country-specific.

From Figure 27 it can be seen that there were no papers focusing specifically on Africa, which emphasises the gap in the literature which will be addressed in this research project. North America included studies regarding United States and Canada. Latin America included Mexico, Puerto Rico and Brazil. Asia included India, Taiwan and China and the European/UK studies were applied in Norway, Spain, Sweden and the UK.

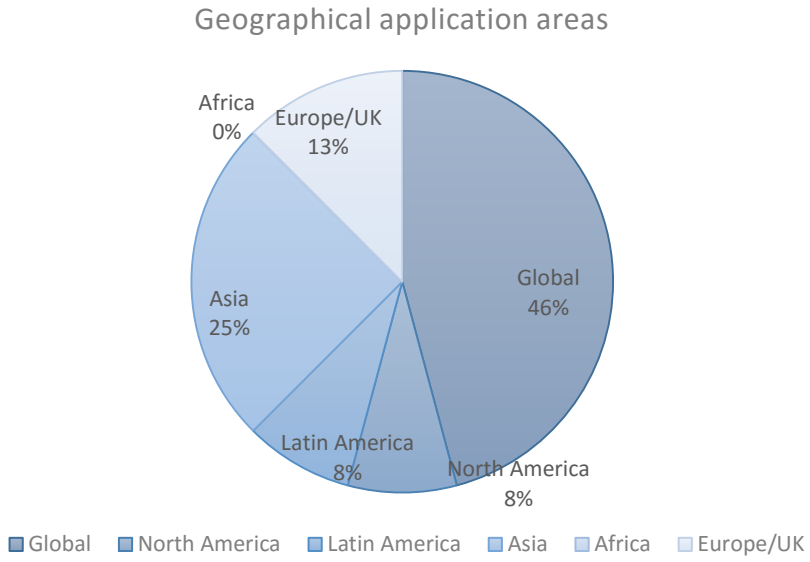


Figure 27: Primary studies' geographical application areas

The literature search aimed to identify studies that adopted an ecosystem perspective. As a result, the primary studies had diverse ecosystem definitions. The different ecosystem definitions are categorised in Figure 28. The ecosystem definition adopted by most studies was that of business ecosystems. This was followed by platform ecosystems, innovation ecosystems, software ecosystems and digital ecosystems. The diverse views on ecosystems highlighted the need to look beyond innovation and

platform ecosystem literature, but also to business and software ecosystems. This investigation can be found in Section 4.2.

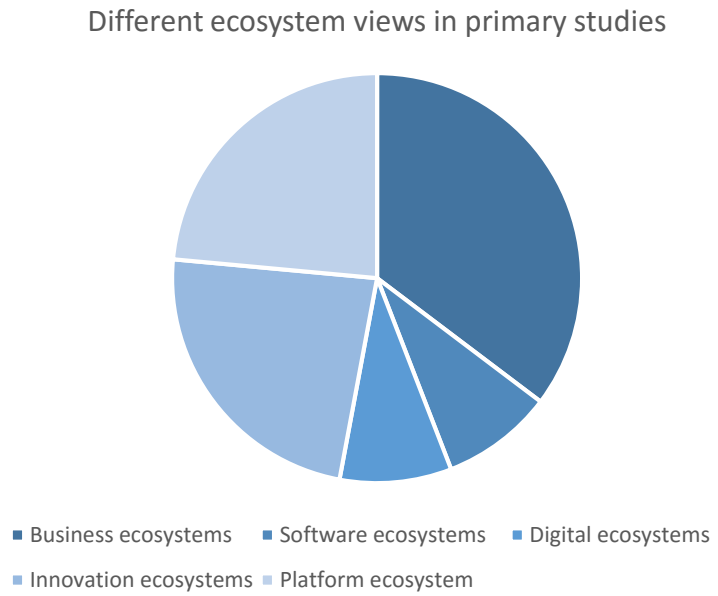


Figure 28: Primary studies' different ecosystem views

As mentioned previously, the systematic literature review forms the foundation for the future research trajectory. Therefore the researcher identified the challenges related to platforms and ecosystems from the primary studies. This was done to indicate possible stumbling blocks for platform owners and to focus the attention on how to manage and overcome these hurdles in future research. The majority of the challenges were regarding the management of platforms and governance of platform ecosystems as indicated in Table 15. It should be mentioned that the references in Table 15 only include primary study references and these topics will be further discussed in Chapter 4 as a part of the conceptual literature review and addressed within the final framework in Chapter 9.

Table 15: Potential challenges relating to platforms and ecosystems

Potential challenges regarding technology platforms and/or their ecosystems	Referring Primary study
Making business decisions regarding evolution in order remain competitive	[79], [80]
Finding a balance between the platform being too ‘open’ and too ‘closed’	[79]
Navigate the landscape where coopetition occurs	[79]
Manage network effects	[79]
Finding a balance between encouraging and constraining innovation of third-party innovators	[79]
Manage expectations regarding ecosystem roles and responsibilities	[81]
Manage competition within the ecosystem and outside the ecosystem (two dimensions)	[81]
Overcome chicken-or-egg problem: balance of attracting users at all sides of the platform.	[82]
Manage tensions within the ecosystem	[82]
How to scale the technology	[83]
Apply management and measurement in an innovation environment	[84]
How to orchestrate an ecosystem	[80], [85]
Manage technical entry barriers when joining an ecosystem	[85]
Manage innovation for short term and long-term sustainability	[86]
Motivate developers to continue in using the platform for their innovations	[86]
Communication and coordination of user-developers	[86]
Develop and apply control mechanisms in the platform	[80]

Therefore it can be concluded that despite the motivation for a management tool to facilitate platform adoption in the South African healthcare context, there is a potential use of a platform management tool by managers due to the complex management landscape and diverse challenges faced.

The primary studies did not all focus on the same actors within an ecosystem. Three broad categories were identified namely the platform owner, developer and end user. These actors fall within the larger ecosystem. It was noted that the three actors have different roles within the ecosystem. The description of each of the three levels is indicated in Table 16 as well as the primary studies that acknowledge each level. The research implication of these levels is that each should be investigated individually in order to better understand the functioning of the ecosystem as a whole. This will also be essential in gaining insight into how to effectively design the platform and manage the ecosystem.

Table 16: Different levels within ecosystem

Level within ecosystem	Description	Primary study level distinction
Platform owner	The owner of a technology platform. Typically responsible for the technology infrastructure and management thereof as well as ecosystem governance.	[85]–[98]
Developer	The complementors that develop complementary products, services or technologies (typically referred to as applications) on the platform through its interfaces	[80], [85]–[87], [89], [91]–[98]
End-user	The end users of the complementary products, services and technologies developed on the platform.	[80], [83], [85], [88], [89], [93]–[98]

This concludes the descriptive analysis of the systematic literature review data. The following section focuses on analysing and discussing the conceptual data from the systematic literature review.

3.6 Conceptual data analysis

The systematic literature review results also led to conceptual insights. These included discussing the diversity of the relevant research landscape, the key concepts related to the search terms and the different ecosystem actors identified from the primary studies.

3.6.1 Diversity of research area

As suggested by Jabareen [39], reading and re-reading the primary studies led to the identification and categorisation of concepts related to the search terms (platform AND technology AND innovation AND ecosystem) and thus the research questions. Firstly, the researcher identified the different areas of research that the primary studies' authors referred to or adopted in their papers. Secondly, the key concepts identified from the primary studies were documented. Thirdly, the different points of view taken up when analysing technology platforms were recognised.

The different research areas the authors discussed in their studies are significant as they identify the multidisciplinary nature of the researched area. For the researcher, this verifies the fact that one cannot look at technology platforms in innovation ecosystems from only one point of view, for example strategic management. The research indicates that the topic stretches much wider and one needs to be aware of other areas of research such as group dynamics, innovation management and open innovation to get a more complete picture. The spectrum of research areas, their concise descriptions and authors in the primary studies referring to that research area are shown in Table 17. The research areas were also categorised into broader categories as shown in the first column of Table 17.

Table 17: Diverse nature of research topic

Categorisation	Research area	Description	Reference(s)
People oriented	Organisational change management	Managing new processes or changes in an organisation such as job transitions and group formation and development [99].	[94]
	Group dynamics	Looking at the dynamics in inter-organisational relationships where multiparty interactions occur.	[100]
	Technology as service delivery (servitisation)	The delivery of a service component through the technology and analysing the technology from this service perspective.	[83], [88], [91], [92], [100], [101]
Economics	Social entrepreneurship	Techniques used when entrepreneurs develop and implement solutions to social issues such as renewable energy.	[83]
	Strategic management	The strategies undertaken by management of a firm to establish and reach its goals taking into account the organisational environment.	[80], [82], [86], [95], [102]–[104]
Innovation studies	Diffusion of innovations	Explains how technology as an innovation spread across a social system.	[95], [105]
	Open innovation	Organisations using ideas across organisational boundaries to facilitate innovation.	[82] [95] [105] [106] [84]
	Innovation management	Planning, implementing and controlling innovation activities in order to realise innovative ideas.	[105] [87]
Systems focus	Technological Innovation System (TIS)	A socio-technical systems perspective to analyse a technological field in terms of structures and processes that support or hamper it.	[87]
	Network theory	Study of complex interacting systems [107].	[100]
	Systems engineering	The overall design and management of the technology considering the complete system life cycle incorporating a process of steps.	[84]
Nature/ biology	Ecology	The biological functioning of ecosystems and how they relate to business and technology ecosystems.	[106]

Each identified research area was categorised into one of five broader categories. The first category included research areas focusing specifically on people and people relations. The research areas involving business management and entrepreneurship were categorised into the economics category. As innovation was part of the key search terms, there were studies focusing specifically on innovation-related aspects including diffusion of innovations, open innovation and innovation management. The studies that adopted a system perspective involving TIS, network theory and systems engineering were categorised together. The last category included papers specifically adopting a biological perspective and how ecosystems function from a biological perspective. As a result, the diversity of fields related to technology platforms in innovation ecosystems identified, act as a starting point for further research in this area.

3.6.2 Key concepts

The researcher identified the most-frequently occurring concepts from the primary studies as a part of the process to identify the key concepts of technology platforms and ecosystems. By identifying the number of occurrences shown in Figure 29, the most-frequently occurring concepts were identified and noted as central research topics for this research. The most-frequently occurring concept was evolution of the technology platform and ecosystem. The second most-frequently occurring concepts were governance and competition. The reason for this could possibly be the importance of successful governance and evolution in order to remain competitive. Other concepts to note were trust within

the value-creating ecosystems, the effect of network effects on the success of a platform and/or ecosystem. Platform design aspects including modularity, scalability and feedback were also included.

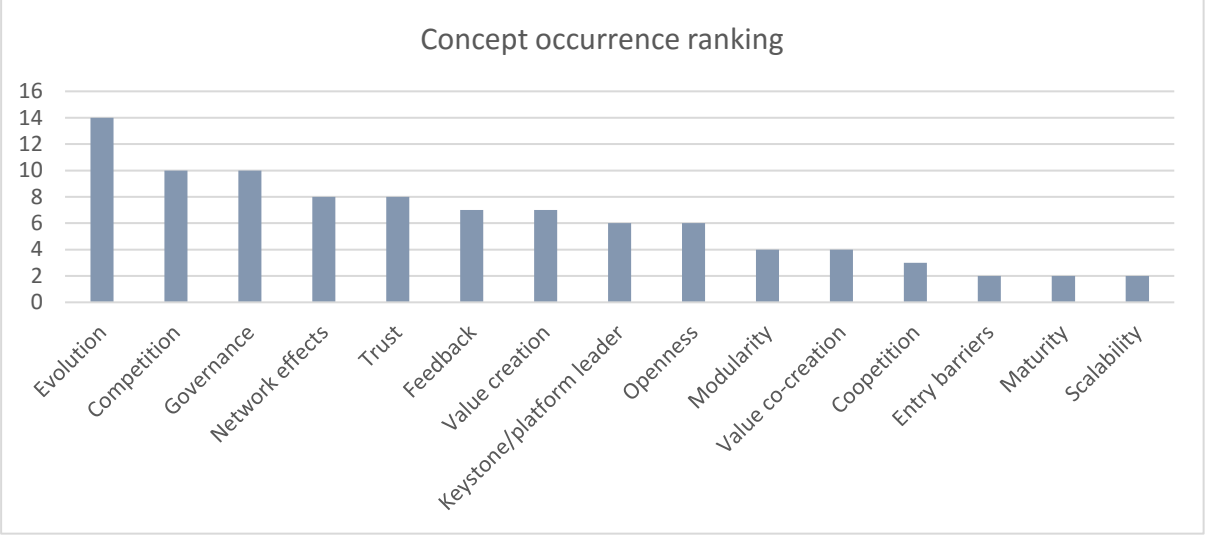


Figure 29: Concept occurrence in primary studies

There were certain concepts that occurred repeatedly throughout the reading of the primary studies and could be linked and categorised with regard to their relation to the search terms (Platform AND Technology AND innovation AND ecosystem). These concepts were extracted from the primary studies and categorised in MS Excel. The key concepts of the search terms are shown in Table 18 along with the primary studies that referenced them. These key concepts provide guidelines as to what aspects to consider and pursue in further research. It also contributes to more fully understanding the workings of technology platforms, ecosystems and innovation and how they relate to one another.

Table 18 also lists the three search categories namely technology platforms, ecosystem and innovation, where after it categorises the concepts into subcategories. For technology platforms, these subcategories include operation and design principles, leadership and user-related categories. Ecosystem subcategories included functioning, leadership, ecological nature and game theory. The innovation concepts were all categorised under the same category as theories in innovation.

Throughout the primary studies, there were three main components that were identified as the key operational principles of technology platforms. A platform owner should take into account how the platform evolves [79], [91], creates value for the firm and its ecosystem [79], [87], as well as the influence of network effects on the platform and its users [79], [95], [108]. Technology platforms need to incorporate specific principles into their core design and architecture [109], which can potentially ease the uptake and diffusion of such platforms in their ecosystems. These design principles enable the platform to define its openness to complementors [86], [108], scale the platform in relation to the user demand [98], [103] and establish its ease of use and integration for platform users. Platform governance incorporates the leadership, company strategy and goals and the value exchange between third parties [81], [106].

The last subcategory for technology platforms was the user-related concepts which are key since the platform is used by the platform owner as well as third parties/complementors. These user-related concepts ensure that the user needs and requirements are satisfied [88], [95] and that they are used for constant improvement [79], [104]. The key concepts identified for technology platforms act as a starting point for understanding the core aspects regarding platform design and functioning.

As a platform connects different participants in its interactive ecosystem within which value is created and exchanged [2], the ecosystem category yields core aspects to consider in technology platform operation. The ecosystem category was divided into four subcategories. The first subcategory included the concepts that influence the functioning of, and operation within the ecosystem such as the simultaneous occurrence of competition and collaboration of firms within the ecosystem [82], [106], the trust that needs to be established between ecosystem participants [79], [87], [106], the entry barriers of the ecosystem [79], and how value is co-created between the participants within the ecosystem [81], [90]. The second subcategory was leadership within the ecosystem which includes the governance of the participants and the need of an ecosystem platform leader [104], [106].

Table 18: Key concepts identified from primary studies

Search category	First Category	Key concepts	Description	Reference(s)
Technology platforms	Operation principles	Network effects/ Network externalities	The value of a technology depending on the number of users adopting it. It allows for the rapid adoption of the platform due to its exponential nature.	[79]–[81], [85]–[87], [95], [108], [110]
		Value creation	The actions that increase the worth of the platform. Value creation can focus on creating value for users as well as stakeholders.	[79], [84], [87], [91], [110]
		Evolution	The platform operates in a dynamic nature and needs to evolve accordingly. The platform also evolves through different life phases from start-up through to maturity.	[79], [87], [91], [98], [106]
	Design Principles	Modularity	Modular components allow for design flexibility and derivative products to be developed with limited resources.	[79], [80], [89]–[92], [110]
		Core and peripherals	The platform should focus on a core function and from there develop peripheral functions.	[79], [80], [108]
		Boundary resources	Enable the platform owner to secure control while allowing third-party participants to contribute. Includes the software tools and regulations at the interface between platform owner and developers.	[91], [92]
		Openness	The degree to which a platform owner opens its architecture to developers including the technology, levels of access to information, rules governing the platform and cost of access.	[79], [85], [86], [108], [110]
		Internal/external	Internal platforms are when the platform is not open to external firms for innovation. External platforms are open for use from external innovators.	[79]
		Evaluation methods	Management of organisation should be able to evaluate the performance of the platform.	[89], [95], [106], [111]
		Scalability	The ability of the platform to adapt if there are large fluctuations in demand/usage.	[88], [98], [103]
	Leadership	Governance	There need to be set rules and strategies to manage the platform in terms of aspects such as openness and aligning strategy with goals.	[81], [106]

Search category	First Category	Key concepts	Description	Reference(s)
	User-related	User needs/ usefulness	To incorporate the needs of the user and ensure it being useful. (User-driven innovation)	[88], [95], [104], [111]
		Feedback	The collaboration with the platform users for feedback regarding new features and products.	[79], [80], [98], [101], [104], [108], [110]
		User toolkits	Third-party developers can be enabled to use a platform sponsor's platform through the provision of user toolkits. The purpose of the toolkits is to allow the non-specialists to design custom products to meet their needs. Examples are software development kits (SDKs).	[85], [86]
Ecosystem	Functioning	Coopetition	The simultaneous occurrence of cooperation and competition within the ecosystem.	[82], [106]
		Entry barriers	Aspects that make it difficult for a party to enter the current ecosystem.	[79]
		Trust	In an ecosystem mutual trust is needed between ecosystem partners as trust affects the operation of ecosystem relationships and risk taking.	[79], [87], [88], [98], [100], [104], [106], [108]
		Value creation /co-creation	The participants of the ecosystem have a joint value creation effort. This is accompanied by shared goals within the ecosystem.	[81], [90], [92]
	Leadership	Governance	Within the ecosystem, it is necessary to govern the ecosystem relationships to prohibit tensions emerging.	[79], [104], [106], [108]
		Keystone firm/ Platform leader	The firm that occupies the central position in the ecosystem and drives the innovation of the evolving ecosystem.	[79], [98], [103], [104]
	Ecological nature	Evolution	The participants in the ecosystem co-evolve and form a part of the ecosystem life cycle where different stages focus on different aspects.	[79], [82], [83], [88], [98], [104]–[106]
		Diversity	Similar to species diversity, industrial diversity refers to the types of organisations. There should be organisations assuming different roles in the ecosystem for robustness and health of ecosystem.	[83]
		Resistance and resilience	Resistance refers to the ecosystem withstanding external stresses without losing functionality. Resilience refers to recovery after a disturbance.	[83]
		Symbiotic relationships	Referring to the interactions and relationships between parties of the ecosystem and the need to work together for balance. There is a balance between the health of symbiotic relationships in the ecosystem and the power exerted by the platform 'leader'.	[103], [104], [106]
	Game theory	Prisoners dilemma	In terms of platform ecosystems, the dilemma is where parties are not willing to	[108], [110]

Search category	First Category	Key concepts	Description	Reference(s)
			open or share their contributions although they want the other ecosystem participants to do so.	
Innovation	Theoretical concepts to consider	Disruptors Dilemma	The need to gain the support of the very parties you are disrupting in order for success.	[82]
		Wakes of innovation	The multiple unpredictable peaks and valleys caused by technological innovation in a socio-technical system [112].	[91]
		Innovation diffusion	Describing how innovation is adopted from the point when first introduced.	[95], [105]

Business ecosystem literature commonly draws from a biological analogy. Therefore, the third sub-category, ecological nature, includes the concepts drawn from the functioning of biological ecosystems. These include the need for ecosystem evolution [105], [106], diversity within the ecosystem [83] and resilience and resistance [83] which are necessary to establish and maintain the ecosystem health. The analogy of ecosystem health draws from research on natural ecosystems and was proposed by Iansiti and Levien [12]. It specifically refers to the performance of the ecosystem in terms of its productivity, robustness and niche creation. This concept will be further discussed in Section 5.5. The last subcategory is game theory, which includes the reference to the prisoner's dilemma within ecosystems [110] [108]. The result of these ecosystem-related concepts is a basic understanding of how the platform ecosystem should operate and the identification of aspects for further research such as ecosystem health metrics.

According to the primary studies, there are certain theoretical concepts that should be considered when assessing the effect that platforms have on the other ecosystem participants and the effect that their ecosystems have on its larger surroundings. Technology platforms could act as a disruption [82] and as a result the effects on society including the occurrence of the disruptor's dilemma, its expected and unexpected innovation wakes [91] and how it will diffuse into society are possible further research areas to investigate. Another conceptual insight was regarding the ecosystem actors.

3.6.3 Three ecosystem actors

It was also recognised that the 26 primary studies focused on different aspects when referring to a technology platform. As mentioned previously, Gawer and Cusumano [79] distinguish between internal and external platforms where an internal platform is a set of assets organised in such a manner that the company can develop and produce a variety of derivative products. An external platform is similar products, services or technologies that provide the foundation upon which other companies can develop their own products, services or technologies.

By adopting the external platform definition, the primary studies highlighted that there were four different focus areas when referring to platforms as illustrated in Figure 30. Firstly, some papers focused on the platform owner. The platform owner is the software developer who establishes and focuses on the architecture and internal design and functioning of the platform [85]. They also determine the level of openness of the platform [108]. An example of this is Apple's iOS. Secondly, some authors focused on application (app) developers who can design their own apps on the platform owner's platform. An example of this is Uber, who designed their app based on Apple's iOS. These developers are influenced by aspects such as platform openness, technical entry barriers and network size [85]. The next area some studies considered were the final users of the app which operates on the platform owner's software platform. Some of the primary papers included aspects on how consumers use and adopt the platforms. The technology perceptions such as usefulness and ease of use as well as

external influences including media and cultural aspects were investigated by Xu, Venkatesh, Tam and Hong [95].

Over and above these three focus areas, there were studies highlighting the interactions at the platform boundaries. There are requirements at the interface between the platform owner and the third-party developers such as an application program interface (API) or software development kit (SDK)[85]. If the platform owner operates as an internal platform, the middle block of Figure 30 will fall away as the platform openness is limited.

These four areas all call for specific design requirements and the researcher should state the specific area of focus when developing design principles or conducting further literature reviews on technology platforms as each of these streams of research highlights different aspects to consider in the technology platform ecosystem.

Figure 30: Different ecosystem levels identified from primary studies

Therefore, the remainder of the research focused on these three ecosystem actors. It is important to note that the technology platform design and development falls within the platform owner component of this ecosystem. This concluded the conceptual and descriptive data analysis and discussion of the systematic literature review data.

3.6.4 Limitations of the review

A limitation of this literature review is that it was conducted using only one research database – Scopus. Scopus was selected as it yielded enough studies to enable the systematic literature review aims to be met. The overarching aim was to familiarise the researcher with the research landscape. This included the identification of key concepts and highlighting further avenues of research. The researcher also acknowledges possible bias as the primary studies' identification process was conducted by only one researcher.

3.7 Chapter 3 Summary

The systematic literature review highlighted the importance of considering all the ecosystem actors individually during the further literature investigation, in order to obtain a more holistic understanding of the ecosystem. This approach was also followed by Schreieck, Wiesche and Krcmar [35] and is similar to Constantinides and Barrett [113]. Investigating each actor individually would allow for a deeper understanding of each contributor to the ecosystem and possibly a better way of governing and controlling the ecosystem.

The primary studies clarified that possible ecosystem actors to consider include the platform owner, the developers and the end users of the products and/or services developed through the platform. From the reading and rereading of the primary studies the basic roles of these actors could be identified and will be further investigated in further research. The seminal authors in the area of research could be identified and will be considered in the following Part of the Research Design which commences with the conceptual literature review in Chapter 4.

The systematic literature review results led to key insights that would direct the further research and development of the framework. Six particular conclusions from the systematic literature review were significant: (1) the multidisciplinary nature of the research, (2) the key concepts discovered, (3) the most-frequently occurring concepts throughout the primary studies, (4) the void of relevant literature for the African context, (5) the challenges identified regarding platforms, (6) the typical ecosystem actors, and (7) the different types of ecosystems.

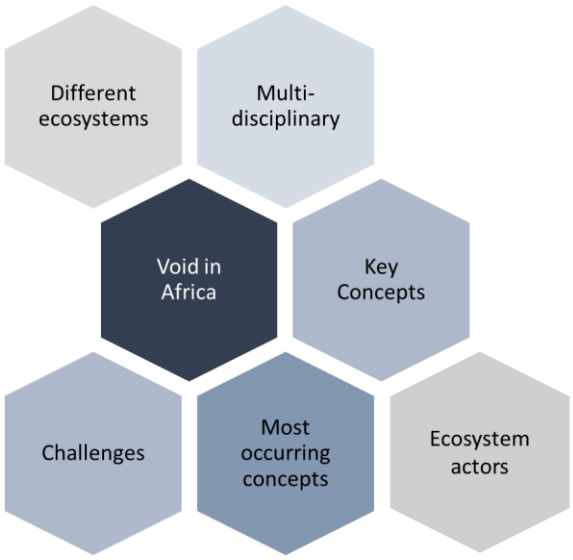


Figure 31: Building blocks from systematic literature review

The building blocks derived from the systematic literature review are illustrated in Figure 31. They were key for the remainder of this research. The multidisciplinary nature of the research directed the researcher to focus not only on one research area, but to explore multiple areas of research when developing the framework. As one of the main aims of the systematic literature review, the key concepts emphasised crucial elements to include in the framework and also formed the basis for further investigation. Evolution, governance and competition were the three concepts that occurred most throughout the primary studies. Subsequently, the researcher directed effort into investigating these concepts and exploring how they relate to platforms and ecosystems. None of the primary studies specifically focused on Africa or South Africa. This substantiated the gap in the literature for research within this context.

The final three building blocks referred to the challenges a platform owner may face, the different ecosystem actors and the diversity of ecosystem types. Seventeen challenges that a platform owner could potentially face were identified from the primary studies. The researcher aimed to assist in dealing with these challenges by incorporating elements into the framework. The analysis of the data also resulted in the identification of typical ecosystem actors and their respective needs and characteristics. These actors included the platform owner, developers and end users. In the remainder of the document, the platform owner ecosystem actor includes the technology platform design and development. The final building block was regarding the different types of ecosystems. As the researcher adopted an ecosystem perspective, it was useful for further understanding and investigation of this approach. The following chapter includes the conceptual literature review where these concepts will be investigated further.

Chapter 4: Conceptual literature review

Chapter 4 key objectives:

- Describe relevant ecosystem literature from a top-down approach
- Clarify the meaning of technology platforms
- Describe the two different perspectives taken towards platforms
- Provide an understanding of platforms through describing some key characteristics
- Highlight the complexity of the balancing act required to manage platforms
- Give a clear depiction of the environmental dynamics of a platform ecosystem
- Investigate the environment in which a platform will operate in South African health
- Investigate existing frameworks, models and tools to guide framework development
- Formulate criteria to select and evaluate these frameworks, models and tools
- Analyse each of the selected frameworks, models or tools for insights that can be related to the final framework

4.1 Introduction

This chapter includes the conceptual literature review which gives an overview of fundamental concepts related to this research. The chapter commences with a breakdown of ecosystem literature and how platform ecosystems relate to technology platforms, followed by an overview of technology platforms. The core characteristics of platforms and their ecosystems are then given. Following the insights into platforms and ecosystems, the ecosystem dynamics, and the investigation into the South African health context, the need for management tools for platform owners is discussed. This includes investigating existing frameworks, models and tools related to this research. The chapter also gives an overview of the South African health landscape in which a technology platform will potentially operate. The context of Chapter 4 within this document and the CFA process is shown in Figure 32. It can also be seen that Chapter 4 is the first component of Part 2 of the Research Design.

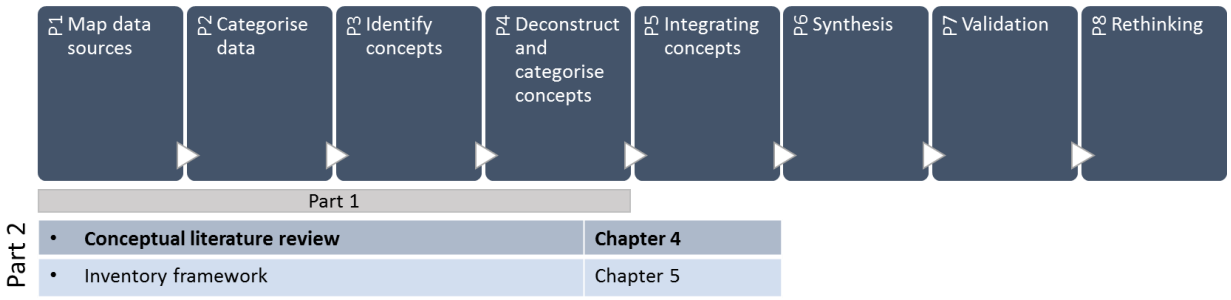


Figure 32: Document context diagram: Chapter 4

4.2 Platforms and ecosystems

Governance of business ecosystems can be challenging for keystone firms. Therefore, the analogy drawn between biological and business ecosystems provides useful insights into the nature of business ecosystems and maintenance of ecosystem health. Business ecosystem research includes work done by Moore [114] and Iansiti and Levien [12]. Criticisms of the ecosystem perspective include arguments that the analogy to natural ecosystems is flawed, the widespread use of this perspective led to unclear definitions of the concept and that there is an absence of set metrics such as those available for industry clusters [115]. Iansiti and Levien [12] also acknowledge the danger of such analogies as ecosystem boundaries can often be difficult to establish. Despite these criticisms, the ecosystem approach is still widely recognised as a legitimate perspective [12], [85], [93], [116], [117].

Two motivations act as the driving forces behind selecting the ecosystem perspective for this study. Autio and Thomas [9] give a general definition for an ecosystem as "*a network of interconnected organisations, organised around a focal firm or platform, which incorporates both production and use side participants"* [9, p. 2]. A platform is therefore key in the formation and operation of an ecosystem and the characteristics of a platform will naturally lead to the formation of a surrounding ecosystem. Subsequently, as this research aims to develop a framework for technology platform management, an ecosystem perspective was adopted. Evans and Gawer [5] established that the governance of such a platform ecosystem is crucial for platform success. We argue that in order to govern such an ecosystem, there should be an understanding of the ecosystem actors and how the platform integrates with them. Gawer and Cusumano [79] also argue that the winner of the competition between platforms is not only determined by the best technology and first to market, but also highly dependent on platform strategy and the ecosystem behind it.

Ecosystem literature has adopted several definitions and perspectives. The following sections will discuss natural ecosystems, innovation ecosystems, business ecosystems, software ecosystems and platform ecosystems respectively. The typical actors within the respective ecosystems and some typical characteristics of each of these ecosystems are summarised in Table 19. It should be noted that the ecosystem metaphor builds on fundamental characteristics such as connectedness and co-evolution observed from natural ecosystems [118]. Therefore, the information included in Table 19 is not exhaustive and is not always exclusive to only one type of ecosystem. Table 19 also indicates notable authors for each of the ecosystems.

Table 19: Typical actors and characteristics of different ecosystems

Ecosystem Type	Typical actors	Commonly referenced characteristics	Notable authors and references
Natural ecosystem	Fauna and flora, all forms of life	Survival, symbiosis, natural selection Generally studied to identify influencing factors Limited conscious decision-making abilities	Moore [114]
Innovation ecosystem	Interconnected organisations, Focal firm or platform	Value creation through innovation Actors make conscious decisions	Adner, Kapoor, Autio, Thomas [10], [115], [118], [119]
Business ecosystem	Business community of interconnected organisations or firms	Value capture Common goal Shared fate Conscious decision-making Keystone firm, dominators, niche players Maturity and life cycle	Iansiti, Levien, Peltoniemi, Teece [12], [117], [120], [121]
Software ecosystem	Actors, organisations, businesses, networks, software	Software components also a part of ecosystem Generally studied to identify growth and success related factors Conscious decision-making	Jansen, Finkelstein, Bosch, Tiwana [116], [122]–[124]
Platform ecosystem	Platform owner (incl. platform), developers end users	Software ecosystem with platform as its core technology Conscious decision-making Platform leader, complementary firms Network effects	Parker, Van Alstyne, Gawer, Cusumano Tiwana, [2], [3], [5], [125]

4.2.1 Natural ecosystems

Natural ecosystems provide a useful metaphor for understanding behaviours specifically within management research [9], [12]. The ecosystem metaphor draws from natural or biological ecosystems to gain insight regarding relationships within the ecosystem [117], the health of the ecosystem [12] and the evolution of an ecosystem [126]. Similarities between natural and business, software and other ecosystems include its finite resources, the effect of ecosystem dynamics on participants within the ecosystem, the occurrence of coopetition within the ecosystem and its internal life cycles [116]. Biological concepts such as selection [117], variation [117] and symbiosis [9], [127] have proved useful within particularly business ecosystem management and understanding.

4.2.2 Innovation ecosystems

Another popular perspective on the ecosystem metaphor is that of innovation ecosystems [28], [119], [128]. Adner [129] states that an innovation ecosystem is "*the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution. Enabled by information technologies that have drastically reduced the costs of coordination*" [129, p. 2]. From this definition, innovation ecosystems are relevant to technology platforms. The reasons for this statement are that a platform could function as the technology which enables the ecosystem to coordinate and also that technology platforms enable innovation for third parties through its interfaces. When such an ecosystem is governed appropriately and functions adequately, it allows for value creation and innovation that would not have been possible by a single firm [129]. It is however clear that a fundamental factor for the success of an innovation ecosystem is a leadership body that places the health of the ecosystem above that of individual goals [130]. Along with leadership, other attributes include communication, trust, social responsibility and alignment [130].

In their systematic literature review aiming to unpack innovation ecosystems, Gomes, Facin, Salerno and Ikenami [118] suggest that an innovation ecosystem largely relates to value creation, whereas business ecosystems relate to value capture.

4.2.3 Business ecosystems

Drawing from Moore [114], Rong [131] defines a business ecosystem as "*a loosely connected business community composed of different levels of organisations such as industrial players, associations, governments and other relevant stakeholders, who share a common goal and co-evolve, with the purpose of dealing with uncertain business environments*" [131, p. 2].

Some characteristics of a business ecosystem include the interconnectedness and interaction between participants, dependence on each other for mutual success and survival [12], [117], the simultaneous occurrence of collaboration and competition (coopetition) [114], [117], its dynamic nature [117] and the coevolution between the interconnected organisations [117]. Iansiti and Levien [12] suggest that there are three actor roles within such an ecosystem, namely the keystone firm, dominators and niche players. Keystones act as the leader of the ecosystem and its removal will often result in ecosystem collapse. Keystones are therefore vital in maintaining ecosystem health and stability and are needed for value creation and value distribution. Dominators often form a smaller part of an ecosystem and fail to encourage diversity within the ecosystem. They aim to progressively take over, eliminating and expanding into new markets and thereby take over the ecosystem. The final role within such an ecosystem is that of the niche players. These players form the bulk of the ecosystem, but they do not have a broad-reaching impact. These three roles provide metaphors in analysing firm behaviour within a business ecosystem.

Ecosystem health is also a popular concept [116], [132]–[134]. Three metrics of ecosystem health proposed by Iansiti and Levien [12] have been used widely [120], [132], [135], [136]. These metrics are robustness, niche creation and productivity and are derived from the biological metaphor.

Productivity, especially in businesses, should be measured and used to gain insight into how effectively the ecosystem converts innovation into cost reduction and novel products and functions. If an ecosystem can maintain high levels of robustness, it would be able to maintain a relatively stable and predictable environment and absorb shocks from disruptions or changes. A healthy ecosystem should also create new and diverse functions over time (new niches) to maintain good health.

Despite the usefulness of the biological ecosystem metaphor, there are key differences between biological and business ecosystems [116], [117]. Within business ecosystems, participants are able to plan into the future, they can make their own conscious decisions and business ecosystems compete for participants. Biological ecosystems' overarching aim is for survival, whereas business ecosystems also focus on innovation [117] . Apart from business and innovation ecosystems, software ecosystems are also another application encountered in ecosystem literature.

4.2.4 Software ecosystems and platform ecosystems

Specifically in the software industry, firms are connected via a common technological platform and researchers often adopt a software ecosystem (SECO) perspective to understand the operation of these systems [127]. Software ecosystems comprise all the actors that function together as a unit to deliver software and software-related services. These ecosystems are frequently enabled by a common technological platform which allows for the exchange of information, resources and artifacts [116]. Software ecosystems can be seen as a subset of business ecosystems [116].

The software ecosystem definition by Jansen, Finkelstein and Brinkkemper [122] states that a SECO is a "*set of actors functioning as a unit and interacting with a shared market for software and services, together with the relationships among them. These relationships are frequently underpinned by a common technological platform or market and operate through the exchange of information, resources and artifacts*" [122, p. 188].

Referring to the definition of a software ecosystem as being underpinned by a technological platform, a platform ecosystem can therefore be seen as the instance that the relationships within a SECO are underpinned by a technology platform. Gawer and Cusumano [93] view a platform ecosystem as the platform itself and all stakeholders interacting on it. Therefore this research views a platform ecosystem as a SECO that builds around a technology platform. Jansen and Cusumano [116] also deem the role of platforms in SECOs as 'undeniable'. The platform therefore increases in value as its ecosystem grows – more complementary products and services and more users [116], [137].

Governance of the platform is needed in order for the ecosystem to function together as a unit. Although all parties share in the success of the ecosystem, the governance is usually the responsibility of the platform leader or keystone firm [12], [138]. This research aims to define the ecosystem into three levels similar to that of Jansen, Finkelstein et al. [122]. The three levels include the platform owner, the app developers and the end users. In terms of user and open innovation context, the app developers and end users are the most important participants of the ecosystem [85]. These main contributors of open innovation are encircled by the grey oval in Figure 33, on the next page. Jansen and Cusumano [116] describe a SECO consisting of four classifying factors: the base technology, the coordinators, extension markets and accessibility.

Although sharing several aspects with business ecosystems, software ecosystems have their differences. In software ecosystems, both the actors and their software components can have an effect on ecosystem health [116]. For example, the software component developed by an ecosystem actor can increase the use of the platform (positive effect on health) whilst at the same time the actor itself can negatively influence the ecosystem health due to low productivity and robustness (negative effect

on health) [134]. Software ecosystems also comprise not only actors and the networks, but also the software involved [116]. Similar to business ecosystems, software ecosystems have another major difference which is the actors' conscious choice to cooperate. The ecosystem referred to in this research also functions around a central software (technology) platform resulting in a single entity (platform owner) having the largest governing responsibility within the ecosystem. Therefore, the researcher will refer to the technology platform's surrounding ecosystem as its platform ecosystem.

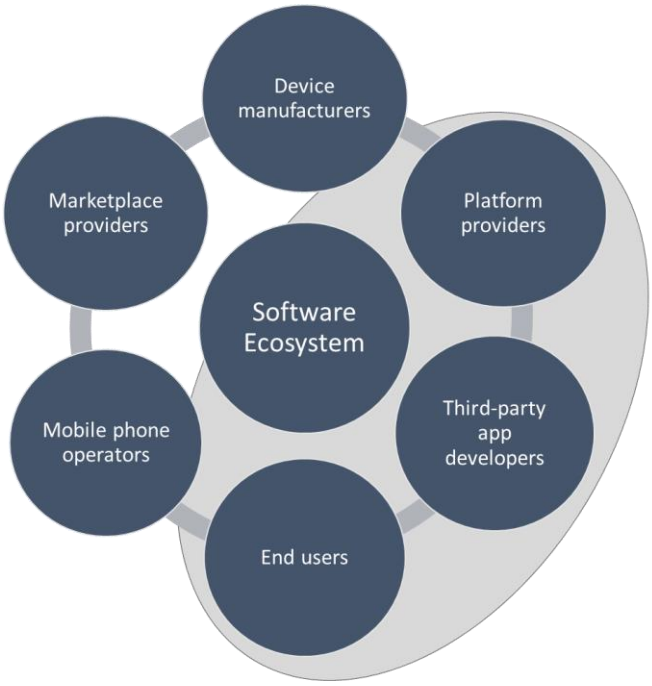


Figure 33: Typical SECO actors [85]

4.3 Technology platforms

The term 'platform' is used in a range of literature resulting in a variety of definitions describing a platform. In the words of Tiwana, Konsynski and Bush [124], "*the notion of platforms refers to disparate things in marketing (product lines), software engineering (software families), economics (products and services that bring together groups of users in two-sided networks, information systems and industrial organisation*" [124, p. 675]. Two of the most common perspectives taken regarding platforms are the engineering or technological view and the economic or transactional view of platforms [109], [139]. Gawer [139] differentiates between these views with the first being a purposefully designed, modular, technological architecture focusing on platform innovation and facilitating economies of scope in innovation. The platform itself is seen as stable with innovation occurring on its modules. This view, however, does not explain platform evolution and competition. A technology platform in the engineering perspective is a "*software-based platform as the extensible codebase of a software- based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate (e.g., Apple's iOS and Mozilla's Firefox browser)*" [124, p. 676].

The second view refers to a type of market which focuses on platform competition and acts as a channel of communication or connection between two or more categories of consumers. The platform coordinates these interactions and generates value influenced by the platform's pricing strategy. An economic or transactional perspective definition of technology platforms is given by Parker et al. [2] as "*a platform is a business based on enabling value-creating interactions between external producers and consumers. The platform provides an open, participative infrastructure for these interactions and*

sets governance conditions for them. The platform's overarching purpose: to consummate matches among users and facilitate the exchange of goods, services, or social currency, thereby enabling value creation for all participants" [2].

Evans and Gawer [5] identified four types of platforms namely transaction platforms, innovation platforms, integrated platforms and investment platforms. These platform classifications also correlate with the economic and engineering views of platforms. Transaction platforms act as intermediaries that facilitate transactions and exchanges between different parties. This relates to the economic or transaction perspective of platforms. Innovation platforms align with the engineering perspective in that they form the foundation which enables other parties, organised in an innovative ecosystem, to develop complementary products, services or technologies. Integrated platforms act as both transaction and innovation platforms. The final platform type, investment platforms, is not applicable to this research.

Moazed [140] states that there are many different types of platforms with diverse ways of creating value and these can be divided into two main categories namely 'maker' and 'exchange' platforms. Maker platforms enable third parties to create content on top of the platform while exchange platforms facilitate exchanges between producers and consumers to create value. These categories therefore also correspond with the two platform views (engineering and economic views) defined previously. Table 20 aims to clarify these concepts and provides examples.

Table 20: Comparison of two perspectives on platforms [35], [139], [141]

	Technology/engineering perspective		Market-oriented/transactional perspective	
Typical definition	"*The extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate (e.g., Apple's iOS and Mozilla's Firefox browser*" [124, p. 676].		"*A platform is a business based on enabling value-creating interactions between external producers and consumers. The platform provides an open, participative infrastructure for these interactions and sets governance conditions for them. The platform's overarching purpose: to consummate matches among users and facilitate the exchange of goods, services, or social currency, thereby enabling value creation for all participants*" [2]	
Purpose(s)	Value co-creation, innovation		Matching users, facilitating exchanges	
Platform examples	Closed development	Fitbit, Salesforce	Payment Platform	PayPal, Snapscan
	Controlled development	iOS, Windows	Product/services market platform	Amazon, eBay, Uber, Airbnb
	Open development	Linux, Android	Social networking platform	Facebook, LinkedIn
Relevant variables	Openness, control, boundary resources, innovation rate, platform adoption, platform stickiness		Market sides, network effects, competitive strategy, platform adoption	

Despite the different perspectives on platforms, Baldwin and Woodard [109] argue that platforms have common roots in engineering design. They state that platform architectures are fundamentally the

same and that any platform system comprises of three components namely the evolvable complements, the stable core components and the versatile and flexible interfaces between the two.

In another attempt to bridge the two views on platforms, Gawer [139] summarised and compared the contributions, arguments and characteristics of each view and concluded that there is a commonality between the two in that "*platforms create value through economies of scope in supply and/or in demand*" [139, p. 1239]. As a result of bridging the different views, Gawer [139] conceptualised a platform from an organisational perspective comprising three components. Firstly, it is an evolving organisation that coordinates agents who innovate and compete. Secondly, it creates value though enabling and harnessing economies of scope. Finally, such a platform involves a modular technological architecture.

Beyond the two main platform perspectives, there are also a number of classifications of platforms in organisational settings. Gawer and Cusumano [93] classify organisational platforms into internal and external platforms. Internal platforms operate within a single firm with closed interfaces and are managed by the firm's managerial hierarchy. An external platform involves industry firms governed by its platform leader and is innovated upon by its complementors who utilise the platform through open interfaces. As a result, platforms not only operate in diverse industries, but platforms are also often embedded within other platforms [79]. In Facin et al. [89], software platforms are seen as the programs running between the hardware and application. Therefore, platforms could also refer to the many 'middleware' software components that provide services to applications and application developers.

This research adopts the definition of a platform as a technology that acts as a foundation used by multiple firms and that connects multiple actors together for a common purpose [137]. In this context, the technology refers to a software platform that enables developers to innovate upon and provide products and services to end users. Therefore, in the remainder of this document, technology platforms and software platforms refer to the same thing. The value of such a platform is directly related to the number of complementary products, services and users that adopt the platform (network effects). This supports the importance of maintaining the health and good governance of the software and its ecosystem. The research also aims to develop a framework for integrated platforms as defined by Evans and Gawer [5], and will therefore investigate both economic and engineering perspectives in order to develop a generic framework.

In their presentation regarding concepts for platform ecosystem design and governance, Schreieck et al. [35], compared the literature focusing on the technology-oriented view of platforms and economic-oriented views. It could be seen that the economic-oriented view had less research on openness, control and technical design. The technology-oriented view lacked research on competitive strategy and pricing and revenue sharing. Schreieck et al. [35] therefore recommend that future research can integrate the economic and technology perspectives to gain insights into platform ecosystems. They also argue that no platform-based business can be completely described by only one of these two perspectives and existing literature rarely adopts this integrated viewpoint. In their survey, Evans and Gawer [5] concluded that both transaction and innovation platforms are moving towards becoming integrated platforms.

The researcher is taking this approach to include both views for three reasons. Firstly, as mentioned previously, platforms are becoming embedded in other platforms and therefore a more comprehensive understanding of both views can only be beneficial. Secondly, as Gawer [142] argued, the engineering perspective literature often lacks depth in competition and evolution. Platforms should also harness economies of scope and value creation opportunities which are recognised more abundantly in economic perspective literature. Therefore, as also proposed by Schreieck et al. [35],

we argue that both perspectives can learn from each other and aid in a generic integrated platform understanding.

4.4 Understanding platforms and platform ecosystems

As discussed previously, platforms can refer to many different things. For the framework developed in this research the focus is on integrated platforms, which are the combination of innovation and transaction platforms [139], and therefore include both the engineering and economic perspectives as shown in Table 20. Platforms can also be internal or external, affecting the relevance of the framework and ecosystem actors involved [93]. This will therefore result in diverse views on what a platform is and how it should function, but there are certain characteristics of platforms and their ecosystems that the researcher finds fundamental for understanding a platform and its ecosystem. These characteristics relating to technology platforms, platform ecosystem or both will be discussed next.

4.4.1 Value creation

Platform owners have to examine the core purposes during the platform design stages and evaluate how the value will be created, captured and delivered. Platforms can create value by the interaction of actors through the use of the platform and are therefore seen as hubs for value exchange [37]. However, the details of value creation, capture and delivery will depend on the platform type [5]. Platforms also have the ability to scale the captured value exponentially by being software based [11]. Platform value creation is affected by choices regarding governance, competition, openness and managing of consumer expectations [37]. This value also has to be captured and delivered, bringing the following concept to attention: pricing and monetisation. The pricing and monetisation will define the revenue-sharing throughout the ecosystem [35]. These concepts also define the costs associated with joining the ecosystem and using the platform ecosystem.

Another aspect to consider regarding value is that of the platform itself. The measure of value of a platform can differ greatly, for example the value of Wikipedia increases with an increase in articles and readers, whereas Ebay's value increases with more buyers and sellers [35]. The platform itself therefore becomes more valuable based on two things: (1) more complementary services, products or technologies, and (2) more users [143]. A valuable characteristic of platforms is network effects which encourage these groups to grow exponentially within the ecosystem.

In a platform ecosystem, the value is co-created by the collaborative effort of the ecosystem actors. As each actor fulfils a different role, the value proposition will differ for each of the ecosystem actors, highlighting the need to define actor roles and relate the value to the desired value proposition of the actors [35]. Value co-creation in the ecosystem is also dependent on the value distribution channels, context, monetisation approach taken by the platform owner and the platform boundary resources [35]. Apart from creating value, the presence of network effects is also characteristic of platforms.

4.4.2 Network effects

Network effects are one of the driving forces behind successful platforms. Network effects refers to the dynamic cycle in which users of a platform attract more users and thereby result in self-reinforcing growth of the ecosystem [5]. As a result, the platform itself becomes more valuable as more users join, and more value is created through the platform. There are two main types of network effects: direct and indirect network effects. Direct network effects occur when the users of the platform attract more external users to join the platform. Indirect network effects refer to the instance when the increase of users on one side of the platform attracts more users of the other side of the platform [5]. Network effects are therefore also a reason why platforms scale rapidly without constant and deliberate effort from the platform owner. A platform owner should, however, focus on ways to encourage these network effects in order to grow the platform ecosystem and get a competitive advantage over competing ecosystems.

4.4.3 Competition

In traditional pipeline businesses, Porter's 'five forces model' has been used with great success. Although this model was developed in 1979 [144], it is still commonly used. However, the frequently undefined ecosystem boundaries, rapidly shifting environment and significant presence of network effects in platforms and platform ecosystems have demanded additional considerations in understanding competition [11]. There is also a difference in focus between traditional pipeline businesses and platform businesses [11]. Pipeline businesses focus on sales that result in revenue, whereas platforms focus on the number of interactions facilitated by the platform. A strong up-front design is therefore crucial as it will enable or disable the needed interactions to take place via the platform. Platforms also aim to minimise entry barriers in order to maximise value creation, in contrast to pipeline businesses which purposefully erect barriers [11].

Competition can be viewed from more than one dimension in the case of platforms and their ecosystems: (1) competitive forces within the ecosystem and (2) competitive forces exerted by other ecosystems. Competition within an ecosystem can lead to tensions between actors, which should be managed by the platform owner [109], [143]. Platform owners can decide to extend their functionality or scope into the domain of some of its complementors which results in tensions within the ecosystem. This action is known as 'envelopment' [3], and is considered an entry barrier that developers/complementors consider when joining an ecosystem. If a platform has a reputation for crossing its boundaries and constantly moving into the domains of its complementors, it may have a negative effect on the number of complementors joining the ecosystem.

Other forces of competition within the ecosystem involve the platform openness and developer community. An inherent tension occurs between the platform owner and complementors. This tension is as a result of the threat that the openness may lead to cloning of the platform [109], [143]. However, the platform openness is key as it allows for complementors to innovate. Competition can also occur amongst developers, particularly if there is low diversity amongst the developer community. Internal ecosystem competition could lead to undesirable tensions which affect the ecosystem health. An ecosystem should, however, also aim to share knowledge and collaborate for increased innovation and a sense of community amongst developers, leading to the simultaneous occurrence of collaboration and competition within a platform ecosystem.

The platform's competitive strategy should acknowledge the balance between competition and collaboration (coopetition) within the ecosystem, as well as the strategy to maintain competitive advantage with regards to external ecosystems [35]. A key part of the competitive strategy requires the monitoring of external competing ecosystems that may steal away ecosystem actors or move into the scope of the platform ecosystem (known as envelopment [145]). A platform owner should also monitor disruptive and emerging technologies that may influence the platform in the future.

However, there have been criticisms to viewing competition as the driving force behind a platform strategy. Thiel [146] highlights the concern that a platform idea should be novel and should therefore not have a 'clone' business or ecosystem that it directly competes with, as then it would not be truly novel. Although a platform should be original with its core value proposition and functionality, there are several aspects at the platform's software architecture level that are common amongst most platforms.

4.4.4 Architecture

The architecture of a platform should allow certain architectural components to remain fixed, while other components change over time [109]. It thus implies that the platform architecture firstly comprises stable and reusable core components with low variety but high reusability and secondly, it comprises peripheral components that are variable and have a high variety but low reusability. These

are generally referred to as the complements of the platform [109]. Developers can therefore also be seen as complementors. The platform and its complements interoperate through the predetermined design rules and boundary resources or interfaces. By splitting the system into these modular components, the design and production across the platform is split across multiple firms allowing for more innovation and specialisation to occur.

This fundamental modular architecture of platforms in the context of this research is explained in Figure 34. The platform owner provides the stable core platform with high reusability, but low variety. On top of this modular platform, the developers (complements) build their own variety of applications resulting in new innovations. This can be linked to the health of the ecosystem seeing as diversity is one of the requirements of a healthy ecosystem [133]. The interfaces involve the boundary resources (software development kits (SDKs) and application programming interfaces (APIs)) and determine the ease of use and integration of the core platform with developers. These interfaces also reflect the decisions regarding platform architectural openness which the platform owner needs to establish [96]. Through adopting this architectural design, the core platform can be reused without extensive modification to produce a variety of applications. The platform owner is also responsible for establishing standards, licencing requirements and the distribution of decision rights within the ecosystem [124].

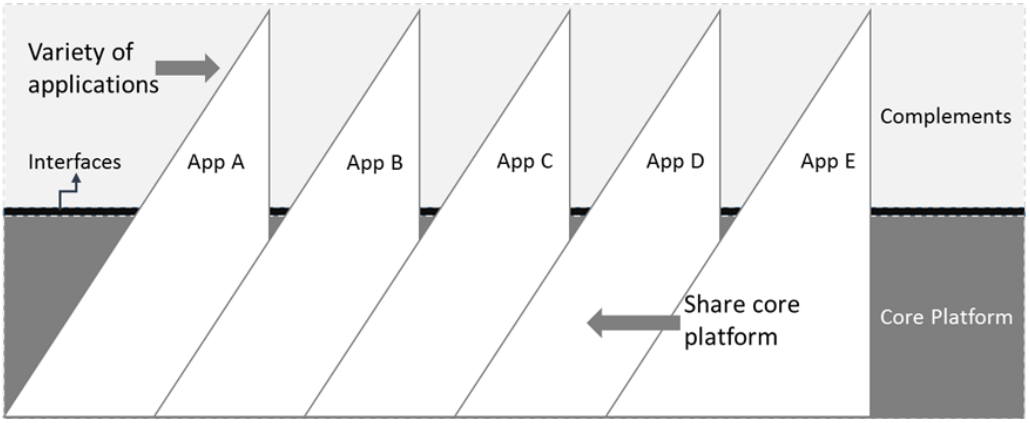


Figure 34: Illustration of a typical modular software architecture

Adopting a Service Oriented Architecture (SOA) is one such a way that modularity can be obtained, especially in the dynamic health environment where interoperability is key [7]. Service Oriented Architecture uses standard, structured and reliable application programming interfaces (APIs) to define how systems and their subsystems interact. This allows for a complex system to be broken down into several black boxes interfacing via their APIs. This breakdown reduces the cost and complexity of the system and increases its modularity and ability to adapt to a dynamic environment. It also allows for easy addition of new functionalities or existing functionalities to be updated or abandoned [147].

A popular application of platforms is that of Platform as a Service (PaaS) [132]. Platform as a Service is a cloud computing category that enables developers to develop, run and manage their applications without having to buy and manage the underlying software and/or hardware [148]. PaaS reduces the complexity of development and provides the facilities for development of applications on the web. It also moves the software from computers onto the cloud (web) for anytime and anywhere access. It allows developers to focus on development and innovation by means of reducing risk, the amount of required infrastructure, lowering costs, enabling rapid development, providing reusable code and integration with other web-based services [148]. Developers do not have to focus on services such as scalability or security [149]. Figure 35 indicates a typical PaaS setup. The two other components of cloud computing are Infrastructure as a Service (IaaS) and Software as a Service (SaaS).

In order to provide the aforementioned benefits to developers, PaaS requires two mandatory integration points. Firstly, the PaaS solution has to integrate seamlessly with underlying IaaS resources by means of APIs provided by the IaaS. Secondly, the PaaS has to integrate with the SaaS layer including runtime support where applications can be developed. Larger enterprises often resort to building their own PaaS environments tailored to their needs [149]. Table 21 includes each of these components and gives some examples for clarification.

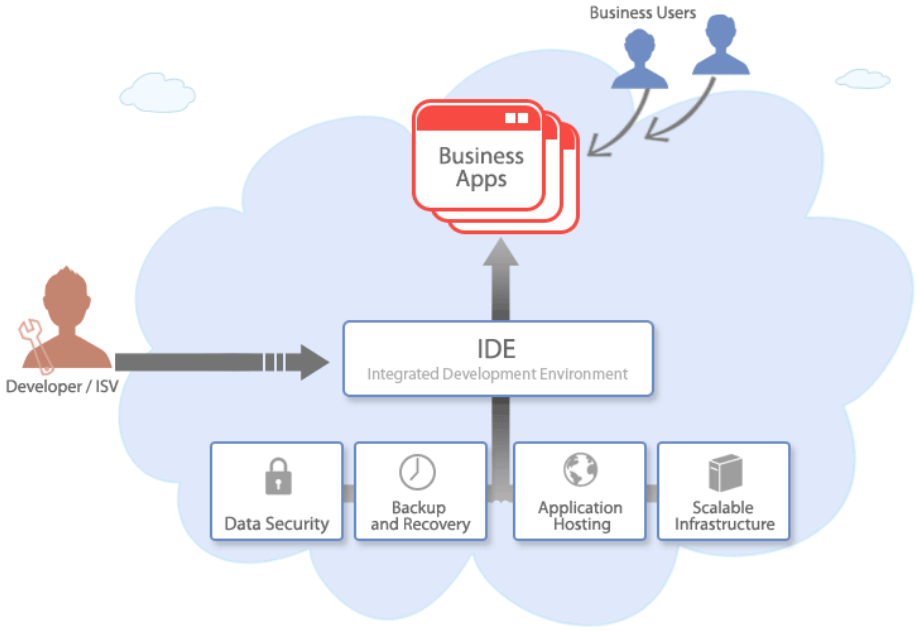


Figure 35: Typical PaaS Setup [148]

Table 21: Clarification of cloud computing services

Cloud layer	Description	Examples
SaaS	Consume: Functional specific applications.	Dropbox, Google Apps, GoToMeeting
PaaS	Build: Includes development platforms, middleware, Runtimes.	Microsoft Azure, IBM Bluemix
IaaS	Host: Underlying hardware or software resources relating to storage, computing resources, network.	IBM Softlayer, Amazon EC2

PaaS can add valuable insight onto the design of platforms and their integration and use of APIs to facilitate modularity, scalability and interoperability. Platform owners can also use certain IaaS, PaaS or SaaS elements when modularly building their own platform.

4.4.5 Modularity

In its simplest sense, modularity facilitates the management of complexity through breaking the system into smaller components which interact through standardised interfaces [139]. A modular system also reduces the scope of information required for developers to design their complements allowing for an increase in specialisation and innovation. Modularity is therefore a central aspect to manage complexity and to facilitate innovation [139]. As a result, the interfaces or boundary resources are key in allowing innovative applications to be developed using the platform.

4.4.6 Applications

An application is a "*subsystem or software service that connects to the platform to extend its functionality*" [3, p. 6]. These complementary subsystems are also sometimes referred to as add-ons, plug-ins, modules and extensions. The platform becomes more attractive with a wider variety of such complements. It should therefore be a key driving force for a platform owner to enable developers to

develop such applications with ease. In this context, application developers are also referred to complementors who develop complementary products, services or technologies. The end user is the customer who uses this product, service or technology developed using the platform [35].

Tiwana [3] suggests four functional elements of such an application. These elements include the presentation logic, the application logic, the data storage and the data access logic. The focus of the platform owner should be to enable developers to build applications using their platform by focusing on all of these functional levels. Usability therefore becomes important for all users within the ecosystem. Firstly, the usability of the platform's boundary resources so as to best enable developers to innovate and secondly, the usability of the applications to their end users. Therefore the ability of third-party developers to create applications depends highly on the openness of the platform.

4.4.7 Openness

Another key principle to be aware of regarding platforms is platform openness. Openness refers to *"the easing of restrictions on the use, development and commercialisation of a technology"* [150, p. 1851]. Most literature refers to openness in terms of the interfaces of the platform [35], [85], [151]. The openness of the platform via its interfaces directly influences the amount of innovation that can occur as it determines the ability of developers to build complementary products, services or technologies on the platform [139]. Interface openness is therefore a major design consideration for platform owners. Despite the amount of research regarding platform interface openness, it is still a balancing act which will differ for each platform owner.

Openness is related to whether a platform is considered an internal or external platform. In internal platforms, the platform interfaces are closed to external parties which limits innovation seeing as external developers are the main sources of innovation. Contrasting internal platforms, external platforms embrace external sources of innovation and the subsequent network effects. Therefore external platforms have to take caution when designing its interfaces and making decisions regarding the extent to which the platform is accessible to external parties. Figure 36 [139] indicates the contrast in interfaces of internal and external platforms as well as other key differences. An internal platform firm only exposes itself within its own firm, whereas an external platform is exposed to the platform ecosystem. The external platform has access to the capabilities of the complete ecosystem, whereas the internal firm's capability access is limited to that of the firm.

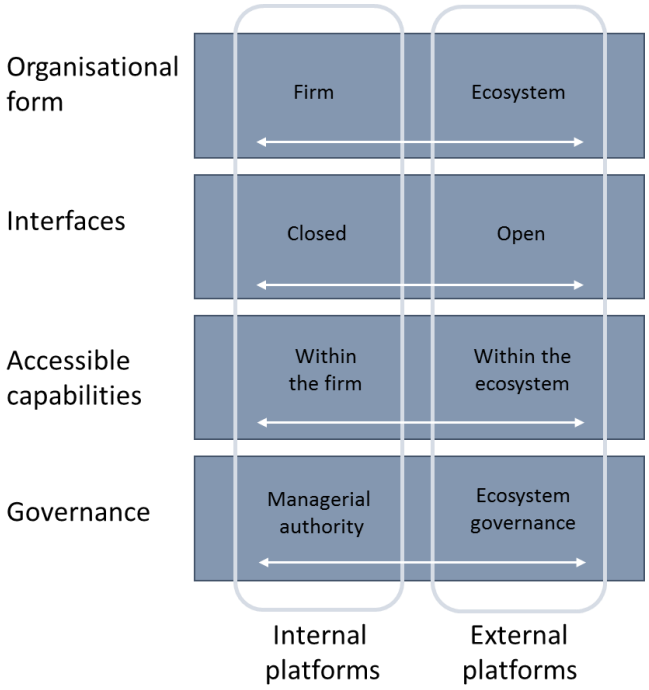


Figure 36: Distinguishing between internal and external platforms [139]

In their open software enterprise model, Jansen, Brinkkemper, Souer and Luinenburg [152], list the variety of openness options for a software producing organisation (such as a platform owner firm). They argue that openness goes beyond only the software architectural interfaces, to parts of organisational governance, the processes related to research and software development, product management, marketing and sales. Decisions regarding the openness of consulting and support processes are also to be considered for transparency towards the rest of the ecosystem.

Transparency, openness and the subsequent ability to innovate can have both positive and negative repercussions. While allowing others to innovate, the platform is exposed to misuse and cloning. Therefore openness is a balancing act for platform owners. It is typically a dynamic decision and should be adjusted over time if needed. One method of controlling the openness of the platform is through its boundary resources.

4.4.8 Boundary resources

Ghazawneh and Henfridsson [15] define boundary resources as the *"the software tools and regulations that serve as the interface for the arm's-length relationship between the platform owner and the application developer*" [15, p. 174]. These boundary resources form the foundation of the transfer of design capabilities from the platform owner to developers and therefore form a part of the governance and co-creation of value in a platform ecosystem [35]. Over and above the need for boundary resources to allow developers to generate complements, boundary resources are also key resources for platform owners to use control mechanisms and to direct ecosystem evolution [15]. A platform owner should carefully design its boundary resources as it can facilitate or limit innovation if not favourably designed.

Schreieck et al. [35] take boundary resources beyond only the software and describe it as consisting of three aspects: the software tools such as APIs, the documentation and data. The data aspect refers to the user data which can be made available to complementors, who were defined in Table 16.

4.4.9 Governance

Governance refers to the "*partitioning of decision-making authority between platform owners and app developers, control mechanisms, and pricing and pie-sharing structures*" [3, p. 25]. Governance is a crucial component that both the technology and economic perspectives of platforms highlight [35]. Tiwana [3] suggests three dimensions of platform governance: (1) decision rights regarding authority and responsibilities; (2) control mechanisms and (3) pricing decisions.

Platform ecosystem governance is also required to facilitate and balance competition and innovation within the ecosystem [139]. However, platform owners cannot resort to traditional value chain governance approaches in their platform ecosystems. Platform leaders have to govern vast amounts of autonomous actors in a manner that encourages desirable behaviour and increases platform and ecosystem health [139]. Therefore platform ecosystem governance requires an understanding of ecosystem as explained in Section 4.6.1 as well as a clear definition of what the platform and its ecosystem are and aim to be. Clearly defining a control portfolio is key as a part of platform governance as the platform model forces the platform owner to give up some control in order to encourage innovation [3].

4.4.10 Control

Control can be used to "*direct attention, motivate, and encourage organisational members to act according to organisational goals and objectives*" [153, p. 149]. Platform owners can use control mechanisms to enforce rules on users of the platform, to encourage desirable behaviours and standards and thereby ensure the best interests of the platform and ecosystem [3]. A platform owner can implement two types of control mechanisms, namely formal and informal. Formal control includes

mechanisms such as gatekeeping through acceptance criteria, process control through encouragement of developers to follow specific development procedures and metric control through which the outcomes are compared to predefined metrics [3]. Process control mechanisms include programming resources, IDEs, SDKs, reference frameworks and models, prototyping tools, integration protocols and testing tools and standards [3].

Informal control mechanisms such as relational control should preferably be supported by formal control mechanisms. Relational control includes the overarching goals, norms and values set by the platform owner with the purpose of influencing developer behaviour. Relational control could facilitate unity and congruency in evolution trajectories. In designing such a control portfolio, a platform owner should aim to keep it simple, transparent, realistic, fair and encourage shared values throughout the ecosystem [3]. Relational control can be encouraged through platform community-building opportunities. Platform owners should also foster a sense of trust as a counterpart of the control [28], [35], as trust in the platform owner is also regarded as an entry barrier which influences whether an actor will join the ecosystem.

4.4.11 Entry barriers

Ecosystem entry barriers affect whether an external actor will choose to join the platform ecosystem. These entry barriers may relate to hardware, software, market, size and the general ecosystem functioning and the platform owner may not always have control over all these potential barriers [85]. Entry barriers can also refer to softer characteristics such as ecosystem stability in terms of faithfulness of ecosystem members, trust and reputation [136]. The platform owner should aim to acquire knowledge on possible entry barriers as part of the ecosystem growth strategy [136].

Entry barriers can also be useful control mechanisms to ensure only desired actors join the ecosystem. This mechanism requires a fine balance as entry barriers that are too low may lead to loss of quality and negatively influence the ecosystem health. On the other side of the entry barrier trade-off is that having barriers that are too high may limit innovation [135]. Despite its effect on profitability and competitive advantage, innovation also adds to the platform's ability to evolve.

4.4.12 Evolution

A software ecosystem strategy should also pay attention to platform and ecosystem evolution [127]. The platform should be able to evolve without compromising on architectural elements such as the stability of its interfaces, security and reliability [127]. The platform ecosystem should also aim to co-evolve with all its actors. Co-evolution occurs when interdependent actor evolve in a manner that leads to the case where a change in actor A results in changes in actor B. Co-evolution is also a result of the interplay of coopetition in such ecosystems [114]. Particularly for business ecosystems, Moore [114] suggests that the ecosystem evolves in four phases. These phases are birth, expansion, leadership and self-renewal or death and they often overlap in practice. Despite the differences between software and business ecosystems, software ecosystems can learn from these evolutionary phases and take them into account as a part of the ecosystem strategy. Table 22 (adapted from Moore [114]) indicates how these evolutionary phases can be translated into cooperative and competitive challenges for a platform owner.

Table 22: Life cycle phases and how they relate to coopetition challenges [114]

Phase	Cooperative challenges	Competitive challenges
Birth	Work together with customers and establish new value propositions	Protection of novel ideas. Gain input from desired ecosystem partners
Expansion	Scale up and achieve maximum coverage	Defeat similar platform initiatives

Phase	Cooperative challenges	Competitive challenges
Leadership	Establish a vision for the future encouraging the ecosystem to collaborate	Maintain strong bargaining power with regards to ecosystem partners
Self-renewal	New ideas through innovation	Maintain high entry barriers ad switching costs

Throughout all of the evolutionary phases of the platform and ecosystem, a platform owner should monitor the ecosystem health.

4.4.13 Ecosystem health

Ecosystem health draws from the biological ecosystem analogy where ecosystem actors all have a shared fate. The shared fate highlights the need for maintaining ecosystem health [12]. Ecosystem health can be linked to sustainability and prosperity of the ecosystem [134].

Jansen [132] and Den Hartigh, Tol, and Visscher [133] all split business ecosystem health and its metrics to relate to both partner and network health. Manikas and Hansen [134] proposed that in a software ecosystem, the ecosystem health can be attributed to the actors, the software itself and the orchestration of the ecosystem. The actors and software are divided into individual health and network health. Manikas and Hansen [134] also distinguished between the health of an actor and the health of the network of actors. When referring to the software affecting the ecosystem health, the software comprised the software component health, the platform health and the software network health. Therefore, software ecosystem health is affected by several different components and relationships. In the context of this research, it can be translated into five components: (1) the three ecosystem actors and their relationships, (2) the platform owner firm itself, (3) the software components, (4) the external environment and the (5) software platform, as shown in Figure 37.

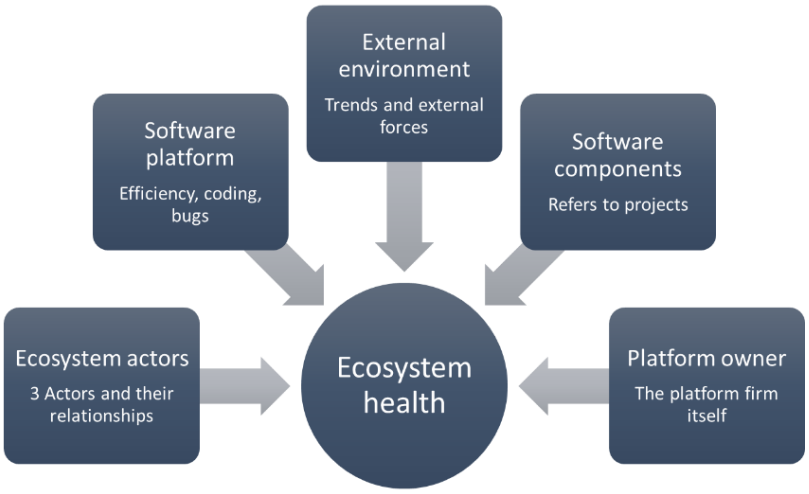


Figure 37: Ecosystem health components to consider as orchestrator of the platform ecosystem

Platforms and their ecosystems are therefore dynamic and complex entities to manage. The responsibility of the platform owner to manage the platform, govern its ecosystem and maintain its health subsequently results in many trade-offs for which there may not be one specific solution and adds to the complexity of the balancing act typically performed by platform owners.

4.5 Platform owner's balancing act

Platform owners have the challenging task of balancing numerous factors relating to the platform and the ecosystem. These trade-offs should be carefully considered and aligned with the platform strategy, goals and vision. In terms of the platform architecture, the platform owner should determine how

open its interfaces will be to external actors as well as how flexible the platform is for developing products, services or technologies [127]. These boundary resources can either enable or constrain developer innovation. A platform owner should, however, consider the possibility of the platform being too open and thereby risking ideas copied by competition.

The platform owner should also establish the control mechanisms and level of control over developers. One such a control mechanisms is the above-mentioned boundary resources. Other formal and informal control mechanisms should be implemented carefully to encourage developers to develop applications. The balance is therefore to maintain adequate control over the platform and developers without limiting innovation [15]. Figure 38 illustrates some of the balancing components that may be experienced by a platform owner.

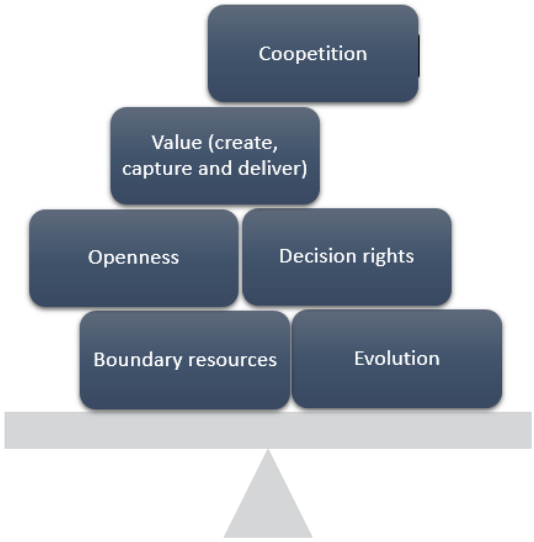


Figure 38: Balancing act components facing a platform owner

There are several entry barriers that also result in trade-off decisions for the platform owner. In general, if entry barriers are too low, the stability of the platform and ecosystem might decrease because of uncontrolled growth and loss of quality (in developers and the applications they develop). This increases the risk of an unhealthy ecosystem. If the entry barriers are too high, innovation is at risk. Potential developers might be reluctant or unable to join the ecosystem due to high entry barriers and they may subsequently flock to competing SECOs, having a negative effect on niche creation. Niche creation is fundamental in a healthy ecosystem [12]. Typical entry barriers to be considered are methods of value creation and distribution within the ecosystem. The evolution of the platform by means of envelopment can also act as an entry barrier, despite its apparent benefits.

Within powerful ecosystems, platforms have the potential to address many different challenges in the modern world. However, technology platforms and their ecosystems require non-traditional management tools. Key components to investigate in order to develop a framework for platform design, development and implementation are the ecosystem dynamics, the roles of each of the ecosystem actors and the South African health context. These will all contribute to an understanding of the context in which such a platform will operate.

4.6 Platform and platform ecosystem operational context

The aim of this section is to investigate the environment in which a platform will typically operate and therefore contribute to a better understanding of what a platform owner would have to design its platform for and subsequently manage. Firstly, the focus is specifically on each of the ecosystem actors, their roles and priorities within the ecosystem. The approach taken to identify the characteristics and

needs of the platform owner, developer and end user independently and as a part of the ecosystem is also described. As this research focuses on technology platforms in the South African health context, the second part investigated the typical environment in which such a platform would operate.

4.6.1 Platform ecosystem dynamics

In their study on platforms and platform ecosystems, Schreieck et al. [35], concluded that most related research focuses solely on the platform owner and neglects to take into account the end user and complementor perspectives. They recommend to investigate all both these perspectives, as the end user is essentially also affected by technological decisions made by the platform owner. Following the work of Constantinides and Barrett [113], Schreieck et al. [35] call for a 'bottom-up' approach to build the platform design and governance approach from the needs and characteristics of the complementors and end users of the platform.

Iansiti and Levien [120] argue that the overall health and evolution of such an ecosystem is dependent on managing the complex relationships between the participants. The ecosystem builds around the technology platform and consequently results in the platform owner taking up a large portion of the responsibility for maintaining ecosystem health [136]. The multifaceted relationships in these ecosystems need to be managed for ecosystem health [51] as owners not only depend on their own platform for survival, but also on the extensions and applications within their ecosystem.

In a software ecosystem context, Jansen et al. [122] and Van Angeren, Alves and Jansen [51] include three ecosystem participants: the platform owner, app developers and customers. Herman, Grobbelaar and Pistorius [53] also state that technology platform literature often adopts the viewpoint of one or more of these three ecosystem participant 'levels' when discussing platforms. As mentioned previously, the ecosystem referred to in this research includes the platform owner, the app developers and end users. A platform ecosystem may comprise additional stakeholders, but in order to define clear ecosystem boundaries for research purposes, the chosen actors were the platform owner, developer and end user. The end users were included as it allows value creation and delivery to be traced from the platform all the way to the final users of the products, services or technologies developed on the platform. This yielded additional insights into platform design and management. Another approach to gain insight from each of the ecosystem actors was to determine what each of the actors can add to the ecosystem. This subsequently led to an understanding of what would attract them to a particular platform and ecosystem. Table 23 indicates value propositions that a platform holds for each ecosystem actor as suggested by Tiwana [3].

Table 23: Linking platform ecosystem actors to platform value propositions [3]

Ecosystem actor	Platform value proposition
Platform owner	1. Massively distributed innovation, compared to traditional product/service 2. Risk transfer, transfer majority of risks and costs 3. Capturing the long-tail 4. Competitive sustainability
App developers	1. Technological foundations that sharpen focus on app development 2. Platforms lower entry barriers by providing a shared foundation to use as starting point for their own work 3. Market access, access to a prospective customer pool
Users	1. Mix and match customisation, depending on their needs 2. Faster innovation 3. Competition among rivals 4. Lower search and transaction costs

Knowledge derived from the previous sections of the conceptual literature review and the systematic literature review from Chapter 3, combined with the platform value propositions from Table 23 formed the foundation of the investigation of the platform ecosystem.

The approach taken was to investigate the requirements of each of the three ecosystem actors in order to identify the issues faced and the context in which each of the specific actors operates. This would provide a comprehensive picture of the ecosystem required to develop the framework. The search was conducted using the Google Scholar, Scopus and Research Gate databases. The search terms used were actor-specific in order to identify studies that would render sufficient information regarding each of the actors. Certain topics regarding each ecosystem actor could be formulated and used as a starting point for the search. Table 24 indicates the descriptions, the topics derived from the literature and how these were used as guidelines in the search process.

Table 24: Example of actor-specific investigation approach

Ecosystem actor	Description of level	Topics highlighted from literature	Examples of how topic was translated to guide search
Platform owner	The platform owner owns and manages the software platform and its boundary resources. They are also usually responsible for the governance of the ecosystem forming around the platform.	Responsible for the software architecture	What does a platform architecture look like?
		Responsible for ecosystem governance	What does ecosystem governance entail?
Developer (also referred to as complementor)	The app developer is the actors either within the platform owner company (internal platform) or third-party companies (external platform) who build complementary products, services or technologies on top of the platform.	Platform owner regulates developer's ability to develop innovative products/services.	How can the platform owner enhance the developers' ability to innovate?
		The platform owner determines entry barriers to the ecosystem.	What entry barriers and motivations for joining the ecosystem can the platform owner control?
End user	The app users are the end users of the applications developed using the platform.	Network effects	How can the platform owner aid in motivating end users to adopt products/services developed on their platform?
		Importance of ensuring usability	

After identifying literature on the ecosystem participants, an extensive reading and rereading [39] of the identified literature followed. The aim was to allow for general understanding of the ecosystem actors and for concepts to emerge from the literature for use in the development of the framework. Each of the three ecosystem actors was investigated and their environment and characteristics established in order to provide additional insight. The platform owner designs the platform and decides on the nature of the interfaces to be shared with developers. Thereby the platform owners enable the developers to innovate by building products, services or technologies. The developers make these available to end users through a variety of distribution channels such as dedicated marketplaces. It should, however, be noted that in commercial apps, the marketplace fulfils a key role in the success of the app. Although the marketplace dynamics are noted, it is not a part of the scope of this research. The first actor investigated was the platform owner, followed by the developers and end users.

4.6.1.1 Platform owner

As the name suggests, the platform owner is the provider of the central software platform. The platform owner can be seen as the platform leader or keystone firm [51]. The platform owner refers to the platform owner firm who is responsible for the underlying technology upon which the ecosystem functions. Therefore the architecture of this technology is a vital part of the success of the ecosystem.

Apart from the technical aspects regarding the software platform and its architecture, the platform owner should make vital decisions regarding the functioning of its firm and its customer base. This includes explicitly stating the scope of its firm, determining the envisioned ecosystem participants and outlining its internal and external environments [154]. Another responsibility of the platform owner is that of governance. Baars and Jansen [155] distinguish between governance and governance structure where governance refers to the processes, procedures and tools that the leader uses to execute their strategy and the governance structure refers to the corresponding responsibility, control and measurement. The platform owner should be aware of its governance and governance structure as the health of the ecosystem is directly linked to successful governance [132].

It can be concluded that the platform owner has three main responsibilities: (1) to effectively design and implement the software platform [2], [143], (2) to maintain the health within its own firm as well as the ecosystem [12], [134] and (3) to govern the ecosystem [35], [124] . The platform owner should therefore be aware of the nature of developers for whom it is designing its platform.

4.6.1.2 Developer

"*Motivation without ability is as worthless as ability without motivation*" – Tiwana [3] regarding app developers.

A developer is defined as the actor who develops applications on behalf of the platform owner in order to satisfy end users of the platform [15]. The app developers are the main sources of open innovations within the ecosystem and can be referred to as user innovators [85]. Depending on whether the platform firm is an internal or external platform firm [93], the app developers either function within the platform firm itself, or as external firms using the platform to develop their own products, services or technologies.

In the fight to attract more users to the ecosystem, referred to as the 'ecosystem war', Ryu, Kim and Kim [156] emphasise the importance of platform providers to develop positive relationships with third-party developers. In the development of their boundary resources model, Ghazawneh and Henfridsson [15] state that platform owners should not only focus on developing apps, but invest more into providing the resources for third-party developer support. This support will differ with regard to the type of app the developer aims to produce. There are three broad categories of apps, namely native, web-based and hybrid. Native refers to apps operating on a specific device's OS, web-based apps run on a web-browser and hybrid apps are web apps functioning within a native browser [157].

In order to provide a better platform environment for the developers, platform owners need to be aware of the challenges that developers face and invest into understanding the environment in which they operate. Through this understanding, platform owners can work towards addressing these challenges and thereby possibly increase their customer base and developer loyalty to the platform. Each platform has different standards, expectations, programming languages, Human Computer Interactions (HCIs), toolkits, other support tools and requirements related to human interface aspects [157]. This results in constant variation for developers when using different platforms. Adding to these challenges, developers also have to deal with fragmentation related to device memory, CPU speed and the graphical resolutions of various devices [157]. Another challenge app developers face is the

monitoring and testing of their apps [157]. The platform owner should could provide customer support and feedback mechanisms for developers using their platform.

Apart from being aware of the challenges that the developers face, another important aspects to consider are the reasons why developers choose to join a particular ecosystem. Software development kits (SDKs) have been observed as one of the major aspects attracting external developers. They are critical for developing quality applications and can be directly related to platform satisfaction and credibility [85], [156]. Ghazawneh and Henfridsson [15] developed a boundary resources model in an attempt to guide the functioning of the software and regulations at the platform interfaces. These interfaces are key in the relationship between the platform owner and app developers. The platform owner should invest in boundary resource design and should modify or constantly develop new boundary resources as a response to feedback and environmental or market changes.

The entry barriers to join a software ecosystem are important to establish as a platform owner [51], [85], [154]. The entry barriers can be intentionally formulated to ensure quality within the ecosystem, or unintentionally such as its reputation, value creation and market size. Platform owners should also be careful when extending their original scope. Developers often consider envelopment as an entry barrier. Envelopment refers to a platform owner 'swallowing' another party as it adds functionality to its original platform [142].

A major reason behind developer adoption of a platform is the openness strategy of the platform. Anvaari and Jansen [158] define this as "*the degree to which a platform supplier allows the platform users to interact with the platform, view, extend or change its components and depends on different technical and commercial aspects such as platform architecture, platform accessibility, platform transparency, licensing state, marketing policy, etcetera*" [158, p. 85]. Therefore, the openness strategy of a firm not only includes the architectural aspects, but also the softer aspects reflecting the reputation and values of the platform owner. A platform owner should aim to open its platform to attract developers and to better enable them to cater for the needs of the desired end users.

4.6.1.3 End user

The end users in this context refer to the parties using the products, services or technologies developed via the platform. The extent to which the platform owner has an influence on the end user varies on the type of platform. As mentioned previously, platforms can either be internal or external platforms, depending on their level of openness [93]. Hence, if the platform firm adopts an internal approach, it will have a high level of interaction with and influence on the end users. If the firm adopts an external platform strategy the level of interaction with the end users will be considerably less. The end users do, however, form a part of the ecosystem and therefore the platform owner should be aware of their roles. A platform owner can investigate reasons behind app failure and gain valuable insight and possible platform improvement opportunities regarding these events.

In the level-specific studies regarding end users, the two most frequently discussed concepts were the usability of the apps [159], [160] and user and usage feedback [161], [162]. Usability is becoming a critical factor due to the increase of software technologies being used to perform everyday tasks as well as the increasing competition within the software industry [163]. High usability can be linked to an increase in user productivity, performance, safety and quality [164]. ISO 9241 highlights three factors that usability evaluations should consider: (1) the person interacting with the app, (2) the goal of the product/service and (3) the context of use including the hardware, materials, tasks to be performed and physical environment of use [159].

There are different models and standards providing different metrics for usability. Some usability attributes include effectiveness, efficiency, satisfaction (ISO Standards in [159]), learnability, memorability, error rate of the system [165] and cognitive load (PACMAD [159]). Leading operating

system (OS) companies also provide their own usability and app design guidelines and how to incorporate these during development and testing of applications [166], [167].

The reasons for buying as well as abandoning apps could also provide end-user insight. Reasons for app abandonment include the availability of better alternatives, being bored with the app, the app crashing or being too slow, the app not being user-friendly and the app not having the features required by the user [168]. The reasons found within the level-specific literature sources regarding the motivations for buying or adoption specific apps included attractiveness factors and how well the app met user needs. Attractiveness aspects included pricing, app description, the app name and icon, the size of the current user base and user reviews of the app [169].

The user behaviour data can be obtained through different methods. Methods of data acquisition include mining of marketplace data, incorporating user feedback mechanisms within the app software, surveys and app testing methods (for example in a controlled environment) [169], [170]. Even if the platform owner does not develop apps within its own firm (in other words an external platform), the platform owner should aim to understand the end-user requirements to be able to provide a better software platform and guidelines for the developers using their platform.

Technology platforms and their ecosystems therefore require non-traditional management tools. By understanding the environment in which the platform and its ecosystem will operate forms a key part of developing the final framework and subsequent management tool. Compounding the dynamics within the ecosystem, technology platforms in the South African Health context have additional implications for a platform owner.

4.6.2 Technology platforms and the South African health context

Accessibility and quality of health-related services are two pressing challenges that the South African healthcare system is facing. South Africa has above-average infant and maternal mortality rates [18], faces a growing number of NCD incidences and experiences the devastating effect of HIV/AIDS and TB cases on life expectancy countrywide [171], [172]. Significant innovation is needed to address these challenges and provide equitable healthcare to all citizens. This section investigates the South African health landscape in an attempt to better understand how a technology platform would and should be designed. This was done by exploring ehealth and mhealth in South Africa, seeing as a technology platform can be classified within the ehealth umbrella.

The South African disease burden is fuelled by risk factors such as unsafe sex, sexually transmitted diseases, alcohol abuse, poor diets and malnutrition [172]. In addition, the lack of adequate healthcare practitioners, specifically in rural settings, is a concern [173]. South Africa has therefore been working towards improving its overall health system [172] with a focus on meeting the associated SDGs [174]–[176]. A health system aims to facilitate healthcare delivery and should respond to a population's needs in a balanced way [23]. This includes improving the overall health status, defence against illness, protection against financial consequences and providing equitable access [177].

An effective, efficient and equitable health system comprises six building blocks: service delivery, health workforce, information, medical products and technologies, financing and governance as indicated in Figure 39, on the next page [31]. These building blocks facilitate the realisation of improved health, responsiveness, efficiency, risk protection and rely on improved access and coverage [31].

eHealth is seen as a powerful tool in the improvement of such a health system [24], [172]. eHealth entails using ICT, such as technology platforms, in health-related solutions. These uses may include the management of health systems and the electronic flow of information and service delivery [16], [178]. Technology platforms could therefore potentially play a valuable role in improving the South African health system. Technology platforms can also be linked to mHealth, a subset of eHealth, and refers

specifically to health-related services delivered and accessed through mobile communication technology [16].

Figure 39: Components of a health system [31]

The South African health landscape and the context in which technology platforms will function is also key in developing a tool for managing a technology platform within this environment. As mentioned previously, technology platform-enabled healthcare solutions include data collection, transfer and population of databases which can be used to improve point-of-care decision-making abilities [16]. Enablers for the increased use of platforms in South Africa include the rapid advancements in digital technology, the extensive use of mobile devices and widespread connectivity compared to other developing countries [17]–[20]. However, there are several barriers to the adoption of platforms in the health environment. The resistance of the health industry to adoption could be linked to the high cost of failure, sensitive data, resource intensity, high regulatory control in the healthcare environment [2], [7], lack of standards and interoperability, lack of integration with existing health systems [16], [22] and concerns related to data ownership and governance [23]. Specifically referring to mHealth projects deployed in South Africa, some of the major challenges include the lack of alignment with health system initiatives and strategies, the absence of governmental input, not using open-source solutions and lack of focus on interoperability [16].

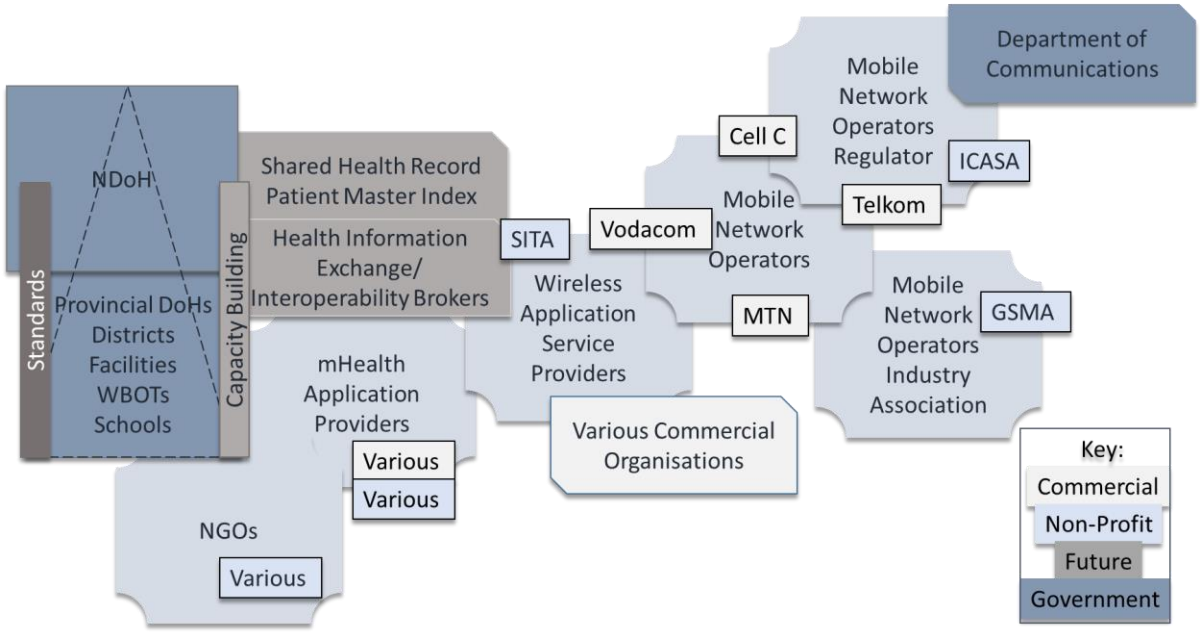


Figure 40: South African mHealth stakeholder high-level overview [16]

In the South African context, there are numerous stakeholders involved in mHealth interventions which emphasises both the importance and challenge of interoperability and collaboration. Figure 40 gives a high-level overview of the mHealth stakeholder landscape in South Africa. The tiered healthcare

system is also illustrated. Interoperability can be defined as "*the ability of two or more ICT systems or components of the business processes they support to exchange information/data and to enable the sharing of information and knowledge exchanged*" [179, p. 22]. Therefore interoperability is fundamental in enabling health technology platforms (such as eHealth and mHealth platforms) to reach their full potential. The reason for this is that it is typically required for two or more ICT systems or components to be able to communicate.

One of the ways in which interoperability can be addressed is through the implementation of standards [179]. The task of standardisation, however, faces several complications. These include working with large datasets and various data formats, standards that involve multiple areas of technology such as content, devices, software systems and infrastructure management [179]. Another challenge is the friction between competing or overlapping standards initiatives [179]. In terms of the health-related data and its utilisation, the necessary systems are also required to capture the data, transform this data into usable data and link with the systems performing data analysis [23].

Another motivating factor for interoperability is the exchange, collection and conversion of data into meaningful information [23]. Health data comprises structured and unstructured data. Structured data is easily used and automated and includes lab results and billing codes. Unstructured data are more difficult to analyse and include clinical notes and natural language. Structured data can be automatically processed and analysed whereas unstructured data often leads to interoperability and challenges related to secondary use of data [23]. Coding and terminology standards (ICD-10 and SNOWMED) and document standardisation approaches (CDA (Clinical Document Architecture)) are examples of standardisation methods used to formulate structured data [180], [181]. Designing, developing and implementing a health platform would require a comprehensive knowledge and understanding of these aspects.

Over and above compliance to laws and regulations and obtaining useful data, the platform and its ecosystem should aim to be interoperable with surrounding ecosystems and other industries. Table 25 illustrates some of the major barriers a technology platform would face in South Africa in terms or resources, IT, existing structures and data aspects.

Table 25: Challenges platforms may face in the South African health landscape

Overarching category	Issue	References
Resource context	○ Staffing shortage and resource constraints ○ Managers or supervision absent ○ Lack of IT department at public hospitals ○ Limited funds ○ Frequent power blackouts ○ Training and digital literacy ○ Sustainability	[6], [8], [16], [32], [182], [183]
IT infrastructure	○ Stability of Internet connections ○ Variance across locations ○ Reliability ○ Sustainability in terms of maintenance ○ Scalability	[6], [8], [16], [24], [32]
Pre-existing supporting structures	○ National Health Insurance ○ Lack of incentives regarding interoperability ○ Compliance to existing standards	[16], [24], [32], [179], [182]
Data collection	○ Standardisation ○ Lack of incentives regarding interoperability ○ Data quality control	[23], [24], [32], [179]

Health technology platforms (a form of eHealth and mHealth implementation) cannot be designed or implemented in isolation and the need for interoperability with other systems is essential for its potential to be reached. A platform owner should therefore be aware of the context in which its health technology platform will function. In order to gain insight into health platform operation, the approach followed was to look at the overall context of a typical eHealth system and thereby determine the landscape in which such an eHealth platform will operate. The eHealth landscape was investigated specifically within the South African health context.

As an initiative contributing towards an integrated health system, the National Department of Health (NDoH) developed the eHealth Strategy South Africa 2012–2016 [24]. This strategy focuses on providing a roadmap for implementation of eHealth interoperability standards. In 2014, the NDoH proposed the National Health Normative Standards Framework (HNSF) for eHealth in South Africa [179]. The aim of HNSF was to form the foundation for the interoperability articulated in the National eHealth Strategy South Africa 2012–2016 and it therefore provides valuable insight into the standards and interoperability requirements for South African eHealth. The scope of the HNSF was developed in accordance with the WHO-ITU eHealth Strategy Toolkit [178].

Figure 41 categorises the different components of a typical eHealth system [184]. A technology platform will form a part of the ICT environment (dashed box in Figure 41) and the correct choice of standards and interoperability specifications are key to the successful functioning of this environment. This interoperability is key to allowing infrastructure and services and applications to interact. The HNSF provides useful guidelines for the development of technology platforms as it focuses specifically on the Standards and Interoperability box shown in Figure 41.

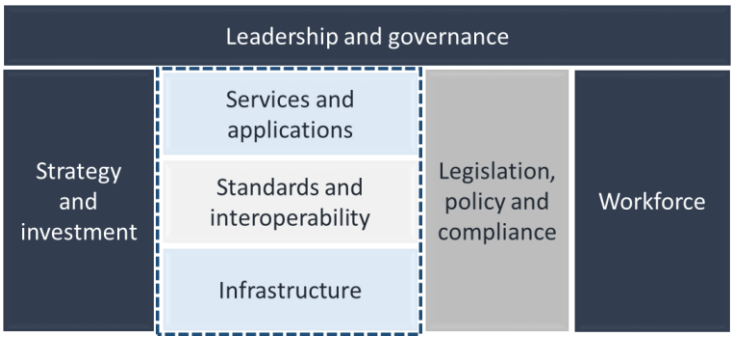


Figure 41: High-level components of an eHealth system[184]

This research specifically considers the ICT environment in which a technology platform will function. Although leadership and governance, strategy and investment, legislation, policy and compliance and workforce are also key building blocks in an effective eHealth system, it falls beyond the scope of this research.

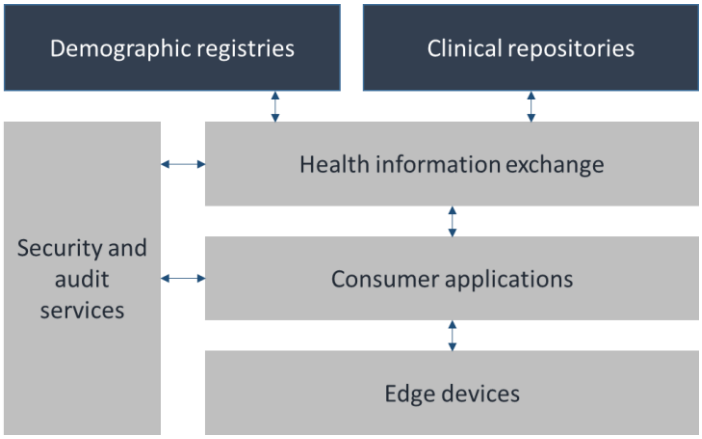


Figure 42: Typical architectural components associated with an ICT component of an eHealth system [184]

Six typical architectural components associated with an ICT component of an eHealth system are shown in Figure 42 [184]. These components illustrate the flow of information and resources of a typical eHealth solution. Relating this to technology platforms, the platform can potentially enable the interaction or flow of information of any two or more of these components (indicated by the arrows in Figure 42). Figure 42 highlights the ability of the platform to interface with other components such as exiting IT systems in clinics and hospitals, the exchange of information, the consumers and security and audit services. Therefore it is vital to understand the ecosystem of components applicable to the platform functionality and scope in order to develop the most comprehensive platform and to ensure interoperability of these components. Table 26 describes each of the components in Figure 42.

Table 26: Description of typical eHealth architectural components. Adapted from [184]

Component	Description of component	Examples
Demographic registries	The storage and matching of demographic information related to various entities that participate in healthcare events.	Patient registry Provider registry Facilities registry Equipment register
Clinical repositories	Clinical repositories are responsible for the storage of data related to healthcare events. These repositories can be general purpose (such as a document repository) or targeted repositories for a specific purpose (e.g., HIV or TB programme repositories).	Shared Health Records (SHR) Lab repositories Imaging repositories Document repositories
Health information exchange (HIE)	The middleware responsible for managing the flow and integrating registries and repositories. It provides the set of interfaces through which the consumer applications and registries communicate. The aim of HIE is to eliminate healthcare data boundaries to allow for timely and informed medical care independent of the location [185].	Jembi developed the HIE that drives the NPR and MomConnect application adhering to HNSF requirements. Access to EHRs, EMRs OpenHIE
Security and audit services	These refer to federated services used to facilitate auditing and authentication.	Within SA: security certificates and protocols ensuring privacy and confidentiality of data flow from applications to the NDoH.
Consumer applications	The gateways, frameworks and application programming interfaces (APIs) enabling the devices to integrate with the rest of the system.	Short Message Service (SMS) gateways APIs and other toolkits Interactive Voice Response (IVR) gateways Health Information Systems (HIS)
Edge devices	The hardware used by the end users to access the applications. Devices used in clinic, mobile, lab, hospital, HMIS	Medical equipment Smart devices
Non-healthcare specific	Depending on the core proposition, there may be other elements of the platform that are not health related	Linking with a bank (e.g. Capitec) for payment methods. Access to external cloud storage.

The typical components a technology platform would need to interoperate with in the larger eHealth system specifically in South Africa have now been established. By understanding the major challenges that can be related to technology platforms in the South African health context, as well as the health environment that the platform would function in, the researcher integrated this knowledge into the framework for design, development and implementation of technology platforms in the South African health context.

Therefore it can be seen that with the particular characteristics of platforms and ecosystems, the balancing act, the dynamics of the ecosystem and the complex South African health environment, that a management tool could be particularly useful for platform owners.

4.7 Management tools

This section aims to highlight and clarify the distinction between platforms and traditional linear businesses. A popular linear business model is also investigated and examined for its usefulness for the purpose of this research. Although beneficial for any business strategy, traditional management tools may not be a best fit for platforms. Technology platforms are different from traditional businesses in several ways. Some of these differences are indicated in Table 27.

Table 27: Differences of platform businesses compared to traditional linear businesses

Difference	Reference(s)
The use of digital technology affects the way in which value is created and distributed	[14], [5]
Co-creation of value between numerous stakeholders may lead to outcomes beyond typical industry boundaries	[14], [3]
The ability to collect vast amounts of data	[14], [7]
The necessity of feedback to evolve and improve platform performance	[14], [93]
The understanding of how interactions within ecosystem create and distribute value	[14], [3]
Competition in the digital age bring different elements into consideration	[14], [5]
Using traditional models such as Porter may not be as useful – for example bargaining of suppliers is low in platform environment compared to crucial bargaining power of customers and users	[186]
Being multi-sided, platforms cater to different user groups	[13], [3]
Instead of value being created upstream and consumed downstream, platforms facilitate value creation and exchange	[13], [2]
The ability of platforms to scale rapidly	[3], [2] [125]
Value of a platform increases with the number of complementary products and services and users	[137], [2] [124] [116]
In the case of platforms and applications developed on it: The software application delivers value itself, the platform is the resource used to create value	[187], [125]

Therefore it is proposed that a platform management tool should be adapted specifically for technology platforms and ecosystems and their characteristics as discussed in Section 4.4. One of the main aims of a platform is to enable value creation and distribution within their ecosystems and the digital nature of technology platforms result in economies of scope. Business models as introduced by Osterwalder, Pigneur and Tucci [188] and recent developments by Zott, Amit and Massa [189] have

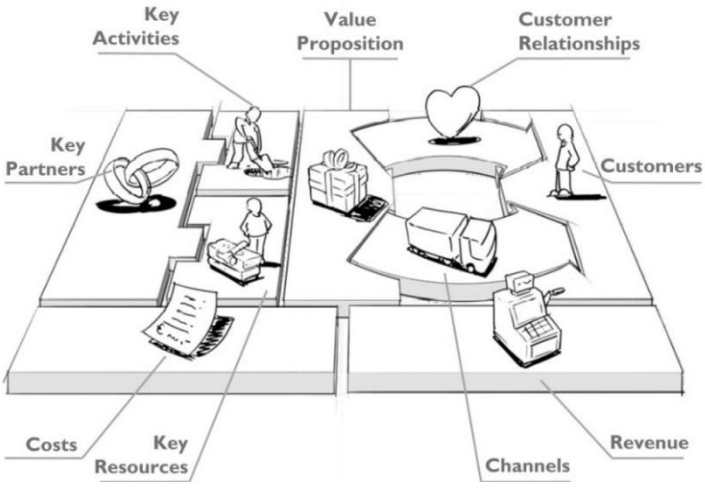


Figure 43: Business Model Canvas by Osterwalder et al. [188]

proven to be useful tools for business planning and strategy. Such a business model can be used to plan value creation and capture on a firm level. With platform businesses, however, the focus needs to shift to the ecosystem of partners and how their value creation, capture and delivery is achieved [81]. The Business Model Canvas (BMC), shown in Figure 43, is a practical tool developed by Osterwalder et al. [188], to ensure a comprehensive consideration of a firm's business, to provide a baseline for business plan evolution and to narrow down the challenges and processes behind a business [190]. This tool and its canvasses therefore provide a good starting point to what a practical and useful tool could look like.

The researcher was inspired by the usefulness and practicality of the BMC to create the management tool tailored for technology platforms. This study draws from the insight obtained from of the BMC to better understand and manage a software platform. Parmentier and Gandia [191] recently redesigned the business model to shift from one-sided to multi-sided markets by emphasising the value propositions, network effects, customer and market segments to consider for each user side of the platform. The BMC has also directly been applied to the business structure component of a software ecosystem where it is segregated into infrastructure management, product, customer interface and financial aspects of the organisation [187]. However, this highlights another distinction of software businesses which is the management needed for both the business and software components of such an ecosystem. Other frameworks, models and tools relevant to platforms and their management were investigated and will be discussed and evaluated in Section 4.8.

4.8 Investigation of existing frameworks, models and tools

An investigation was conducted into existing frameworks, models and tools (FMTs) regarding technology platforms and platform ecosystems. The aim of this investigation was to get an overview of what has been done in terms of FMTs related to the framework developed in this study. As mentioned previously, there is currently no framework for the design, development and implementation of technology platforms in the South African context known to the researcher. Therefore the approach undertaken included breaking the proposed framework down into its basic building blocks, namely platform design, management and ecosystems, and investigating current FMTs related to each of these building blocks. The insight gathered from each building block was then used collectively to enable the development of a better framework.

Although the researcher is aware that these are disparate things as shown in Table 28, there were several reasons why the author investigated existing FMTs. The first reason was that all three can be used to inform a platform owner regarding platform design, management, ecosystem governance and evolution. Secondly, the researcher looked at the content of the FMTs, which included key ideas, concepts, relationships and practical measures. These insights were then translated to the context of the framework developed in this research. The third reason was to identify possible gaps that exist within existing FMTs that could be addressed by the framework. The final reason was to create a benchmark of relevant literature that is useful to platform owners and to build the framework accordingly.

Table 28: Distinguishing between frameworks, models and tools

Term	Definition	Reference(s)
Framework	Broad conceptualisations of the topic under consideration which helps in the organisation of thinking and investigation. Frameworks include lists of variables that aid in generating questions to be addressed.	[38], [192]
Model	Models can be seen as precise assumptions about the relations between variables and their outcomes.	[38]
Tool	"*A thing (concrete or abstract) with which some operation is performed; an instrument*"	Oxford English Dictionary

4.8.1 Investigation approach

The first step of the investigation of existing FMTs was to establish the search criteria to identify appropriate and relevant FMTs. This step of the investigation was done by formulating inclusion and exclusion criteria similar to those used in systematic literature reviews [61], [60]. Similar to Zapata et al. [160], criteria had to be established to evaluate whether or not an FMT was to be included as a part of those to be further investigated and analysed. The criteria were formulated in three main stages: (1) relating to the study objectives and research questions, (2) regarding focus areas highlighted from literature and (3) based on the initial building blocks of the proposed framework.

For the first stage of criteria, the researcher considered the project objectives and research questions which highlighted key aspects that the proposed framework should include. Referring to the project objectives from Section 1.5.2, only the Phase 1 objectives were considered seeing as the outcome of Phase 1 is the preliminary framework and Phase 2 constitutes the evaluation of the framework and is therefore not relevant in constructing the framework. The research objectives and questions for this project as well as the subsequent components to be included in the framework can be seen in Table 29. These components form the first part of the inclusion criteria for the investigation of existing FMTs.

Table 29: Linking objectives and questions to Stage 1 criteria

	Research objective or question	Key components
Research Objectives	RO1: Review the fundamental concepts of technology platforms from an ecosystem perspective through conducting a systematic literature review.	Technology platform characteristics ecosystem
	RO2: Establish the context and requirements of technology platforms within their ecosystems and the dynamics with their ecosystem partners though conducting a conceptual literature review.	Requirements of technology platforms in ecosystem Dynamics within ecosystem
	RO3: Investigate and assess current frameworks, models and tools relevant to platform and ecosystem management	Frameworks, Models Tools
	RO4: Deduce a preliminary theoretical framework or method to be followed to aid in the design, development and implementation of these platforms.	Platform design Platform development Platform implementation
Research Questions	What are current design strategies and requirements for platform development?	Platform design Platform design requirements
	What are technology platforms and their key characteristics?	Technology platform characteristics
	How do technology platforms relate to platform ecosystems?	Technology platforms Platform ecosystems
	What are platform ecosystems and their key characteristics?	Platform ecosystem characteristics
	What are the benefits of health technology platforms?	Health platforms
	What are the principles of evolution of these platforms within their ecosystems?	Platform evolution Platform ecosystem evolution
	Are there differences in platforms in South Africa vs other geographical areas?	N/A
	What would a management tool for technology platforms look like?	Management tool

Over and above the components derived from the objectives and research questions, the systematic literature review from Chapter 3 and the conceptual literature review from Chapter 4 also highlighted specific focus areas related to each of the ecosystem actors. As an ecosystem perspective is adopted for this study, these focus areas were also included into the existing framework investigation criteria. In order to formulate the criteria for existing FMT identification, these focus areas were extracted and listed in Table 30 as the second stage of inclusion criteria for the investigation.

Table 30: Stage 2 criteria from level-specific elements

Perspective/level	Level specific focus criteria (from literature study)	References
Platform owner	Platform design, management, value creation, governance, architecture, evolution, user focused, competition, openness, control, entry barriers	[11], [37], [85], [124], [143], [152], [193]
Developer	Boundary resources and usability, ability to innovate, end-user focused, accessibility, entry barriers	[15], [85], [93], [194], [195]
End user	Usability, accessibility, cost	[161], [194], [196]
Ecosystem	Health, value co-creation, governance, evolution, control, entry barriers	[12], [124], [133], [197], [198]

The third part of the criteria built on the practical aims and building blocks of the proposed framework. The two major building blocks of the proposed framework are platform design and management and platform ecosystems. This resulted in a focus on these two literature streams: (1) literature focusing on platform design and/or management and (2) literature focusing on platform ecosystem management. Complementing the two main building blocks are the overarching aims of the proposed framework. This final stage of criteria was implemented by screening the FMTs and evaluating how well they meet the overarching aims. The overarching aims of the framework are:

1. A practical management tool for platform owners
2. User-centric focus (both developer and end user)
3. Address challenges associated with each level of ecosystem
4. Combine market and engineering views

Paired with these overarching aims, the proposed framework should relate to each of the criteria obtained from the project objectives and questions (Stage 1 criteria). By considering the Stage 1, Stage 2 and Stage 3 criteria, the researcher could identify appropriate FMTs to investigate. Table 31, shown on the next page, includes the Stage 1 criteria relating, each of the final nine FMTs' ratings towards the criteria. The first six FMTs relate to platform design and management and the last three to ecosystem literature (indicated by the darkened headings).

4.8.2 Platform design and management

The FMTs included in this section focus on platform design and management and are therefore significant for a platform owner. The identified FMTs include the Platform Design Framework [37], Platform Innovation Kit [199], Platform Design Toolkit [200], A framework for studying platform evolution [124], the Open Software Enterprise Model [152] and the Boundary Resources Model [15]. Each framework is described, followed by key insights and highlights of the framework. This section concludes with an analysis of these platform design and management FMTs.

4.8.2.1 Platform Design Framework: conceptualisation and application

The platform design framework [37] builds on organisational design literature to present a framework which breaks down the value creation components of a platform and suggests how to coordinate these to reach platform and platform ecosystem goals. The aim of this framework is to facilitate platform design, specifically in the phases prior to and during the early phases of platform launch. The authors of this framework view a platform as a multi-sided market, but also emphasise the need for it to be engineered and designed.

(The remainder of the discussion follows after Table 31)

Table 31: Evaluation of how well selected FMTs relate to Stage 1 criteria

Relate to: (objectives and questions)	FMT1	FMT2	FMT3	FMT4	FMT5	FMT6	FMT7	FMT8	FMT9
Technology platforms and characteristics	✓	✓	✓	✓	✓	✓		✓	✓
Platform ecosystem and characteristics		✓	✓	✓			✓	✓	✓
Requirements of technology platform within ecosystem	✓	✓	✓	✓				✓	✓
Platform ecosystem dynamics			✓	✓			✓	✓	✓
Framework, model, tool	✓	✓	✓	✓	✓	✓	✓	✓	✓
Platform design	✓	✓	✓	✓	✓	✓		✓	
Health platforms									
Platform evolution				✓		✓			
Platform ecosystem evolution			✓	✓					
Main aim of framework, tool or model	Assist in Platform design	Ideate, design and implement platform based business models	Aims to be a guide to design a new platform strategy	Guide studying platform evolution	Establish how open or closed an SPO is	Model of boundary resource design in third party development	Framework for analysis of SECO governance	Used to determine strategies for SECO health	Defines characteristics of a SECO that can be quantified

The focus of this framework is to design the platform for maximum value creation and exchange. Choices regarding governance, competition, openness, quality and consumer expectation management are all considered as having a significant effect on value creation within the platform ecosystem. Based on platform key design challenges and the design of platforms for value creation, four core design problems were identified, namely platform architecture, value creation logic, governance and platform competition. These core problem areas were decomposed into design subcomponents for consideration prior to platform launch. Each of these subcomponents was then translated into key questions aiming to guide the platform owner. The skeleton of the framework is presented in Table 32.

Table 32: Skeleton of the Platform Design Framework [37]

Problem area	Platform architecture	Value creation logic	Governance	Platform competition
Sub-component	Core interaction	Actor roles	Leadership	Platform launch
	Market structure	Value proposition	Ownership	Platform competitiveness
	Key actors	Network effects	Platform rules	Innovation and learning
	Platform openness	Revenue model		Platform growth

The platform architecture section has four subcomponents. Firstly, the framework highlights the core interaction which refers to the main interaction being facilitated by the platform. Secondly, the market structure is considered. This refers to the two-sided or multi-sided market landscape of the platform. Thirdly, the framework looks at the key actors who are the main actors in the market structures and also the providers of the main platform functions. Finally, the framework asks key questions regarding platform openness and its platform openness strategy. The second problem focus area is the value creation logic of the platform. The first of the four value creation subcomponents is the actor roles, which aims to define the role of each of the stakeholders. Secondly, the value proposition of the platform is added, which highlights the different value propositions for the different participants. The third subcomponent refers to the network effects and how they operate. Finally, the framework looks at the revenue model of the platform.

Governance is identified as the third platform design focus area. The subcomponents for governance include platform leadership, ownership and rules. Platform leadership elaborates on the managing authorities of the platform and how platform management will be accomplished. Platform ownership refers to who owns the platform or parts of it. The platform rules subcomponent highlights design issues related to content and services regulation and establishes what participants may and may not do on the platform. The final problem focus area for platform design is platform competition. The first subcomponent of competition is platform launch, which highlights the consideration of access and attraction during this stage of the platform life cycle. Platform competitiveness is the second subcomponent and refers to how the platform will compete against incumbents and elaborates on how it maintains competitive advantage. Thirdly, the framework suggests innovation and learning as a focus area during platform design. This refers to the platform innovation targets and the actors and strategy necessary for platform development. The final subcomponent is platform growth.

There are several factors that stand out from this framework which could be useful in formulating the framework for this research project. The framework has a specific focus on platform design prior to launch and emphasises the importance of a comprehensive platform understanding prior to platform launch. The framework also builds on the four major platform design influencers and challenges which provided its structure and a logical flow. Additional concepts that were highlighted included the importance of platform mission and goals which form around the core interaction of the platform.

Although not classified under environment or ecosystem, the framework does emphasise the importance of defining markets and actors preceding platform launch. A reason might be that these affect the design and launching approaches.

The value creation logic category is another highlight of this framework. Value creation and distribution are the main activities to occur on the platform, it therefore makes sense to design the logic behind this success-driving force. The framework also links the value creation to each of the stakeholders and their corresponding value propositions. Platform competition is considered as a design challenge for platform owners. The framework does include innovation and growth as key components success and maintaining success, but care should be taken into how much competition drives strategy and design. It may be necessary to deploy a unique platform with no similar competitive rivals and therefore competition may not always be the best driver of growth.

The research behind this framework suggests that further research should include qualitative studies that focus on how the design choices are perceived by different platform actors as well as studies which compare different platform designs. The application of the framework stresses the need to involve actors in the platform design process. It also implies that platform businesses require a renewed strategy, leadership approach and redesign of its business model.

4.8.2.2 Platform innovation kit

The platform innovation kit [199] is an online, open-source set of tools that can be used to invent new platform business models. The aim of this kit is to provide platform owners with a proven methodology to "*ideate, design and implement platform based business models*" [199]. This toolset acknowledges the platform economy which refers to the shift from linear businesses to platform ecosystems. The kit is developed based on a multi-sided market model bringing together consumers, producers, partners and the platform owner. All of these stakeholders are connected via the platform and each has a specific role within the ecosystem.

The platform innovation kit consists of eight canvasses, namely the architecture canvas, the environment canvas, the idea canvas, the monetisation canvas, the service canvas, the stakeholder persona canvas, the strategy canvas and the value canvas. These canvasses are to be completed subsequent to each another to facilitate the thought process from the ideation stage to the platform market strategy stage. Each canvas is also complemented with an additional section on its purpose, a 'how to' section and trigger questions for each aspect on the canvas. The canvasses are described in Table 33.

Table 33: Canvasses in the Platform innovation kit [199]

Canvas	Description or role
Architecture canvas	Includes the backend, data, API and connectivity aspects and the platform interfaces for each of the four ecosystem actors. The connectivity category of this canvas refers to platform openness and the subsystems of all the stakeholders. The interface category aims to clarify the stakeholders' interfaces and the core functionalities of the interfaces.
Environment canvas	Helps the platform owner to identify risks and opportunities through an understanding of its environment. The environment within the canvas is divided into key trends, industry forces, market forces and macroeconomic forces.
Ideation canvas	Facilitates the writing of ideas on paper to generate an idea portfolio. The core elements of the ideation canvas include the stakeholders, the platform value proposition, value stream and revenue model.
Monetisation canvas	Canvas is divided into two main categories: total costs and total revenues. Total revenues include the operational costs of the platform, the different unit costs of the platform and acquisition costs associated with each stakeholder. The total revenues comprise the revenues produced by the consumers, the producers and the partners.

Canvas	Description or role
Stakeholder persona canvas	The stakeholder persona canvas is to be completed for each stakeholder. The canvas includes defining the stakeholder's value proposition, its potential assets and capabilities, its goals and performance pressure and possible motivations to join the platform. The motivations for joining the platform are further categorised related to improved customer experience, new business opportunities, operational efficiency and customer needs.
Platform business model canvas	Aids in defining the core value proposition and business model. The core value proposition and business model are defined by considering each of the four stakeholders and independently relating each of them to the platform core and mission, transactions and value propositions.
Service design canvas	Aims to aid in core service design. The canvas core elements include the stakeholders on the one side of the canvas, the platform services in the centre and the key activities, resources and technologies on the other side of the canvas.
Strategy canvas	This canvas has three layers. The first layer refers to the major influencers including stakeholders, business drivers and competition. The second and middle layer refers to the current and desired future position of the platform including its vision and mission. The third layer outlines the key strategies related to resources and markets.

Highlights of the Platform Innovation Kit include its focus on vision and mission of the platform for current and future success and the importance of clearly identifying platform influential factors. Another highlight includes how the kit asks what resources, activities and technologies the platform and platform firm should include in order to fulfil the desired platform service. The layout of the canvasses also displayed creativity as the layouts did not conform to the traditional business model canvas layout. The flow of information and insight from one canvas to the next is tremendously practical and significant. Each canvas is also fitted with a practical aspect including its overarching objective and the steps suggested to complete the canvas. Questions for each canvas are key in provoking thought and act as a catalyst for thought process regarding specific topics. Lastly, the kit clearly defines each ecosystem actor and how they relate to value creation and the revenue model.

4.8.2.3 Platform design toolkit

The platform design toolkit [200] is also an online, open source toolkit with the main objective of obtaining new insights into the platform ecosystem and market and analysing how this affects the platform owner. The process presented within the toolkit stems from two categories: (1) the roles 'playable' within a platform ecosystem and (2) five other key elements that help in understanding a platform and how it can be modelled. The toolkit also assumes that there are two dimensions within the platform design approach: the peer to peer dynamics and the centralised platform vision. The general layout of the toolkit is a main platform design canvas, similar to the Business Model Canvas [188], with separate tools that help the user populate this main canvas. The main canvas is shown in Figure 44.

The key roles that this toolkit acknowledges comprise five entities, including the platform owner, stakeholder, partners, peer producers and peer consumers. These five actors are further categorised into impact-related (platform owners and stakeholders), supply-related (partners and peer producers) and demand-related (peer consumers). A mentioned previously, the toolkit also identifies five elements that help in understanding platforms and how to model them. These five key elements include the transactions occurring on the platform, the channels and contexts which allow the exchanges to occur, the organised services provided to partners, producers and consumers, the value propositions of the platform and finally the infrastructure (tangible and intangible) which ensures successful operation of the platform. The toolkit comprises four main steps, each with a related tool, from which the outcomes are used to populate the main Platform Design Canvas, seen in Figure 44. The four steps, their tools and corresponding objectives are indicated in Table 34.

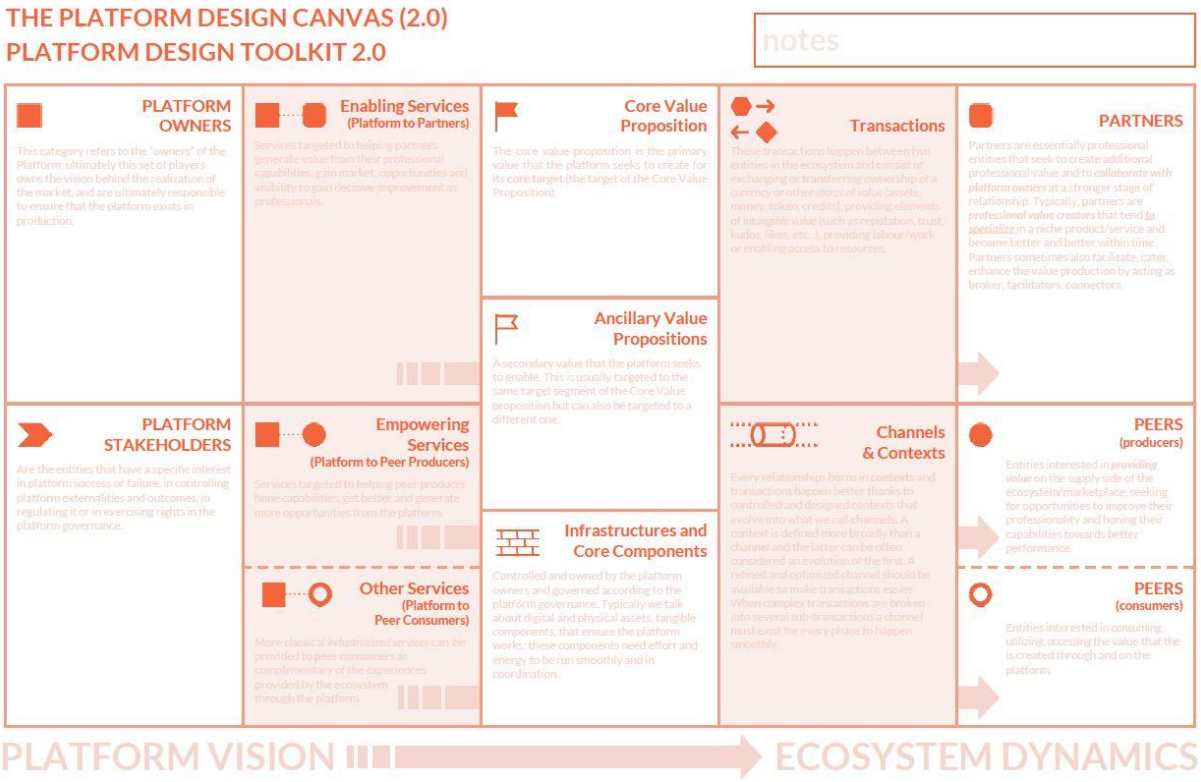


Figure 44: Platform Design Toolkit Main Canvas [200]

Table 34: Platform Design Toolkit four main steps, their supporting tools and descriptions [200]

Step element in toolkit	Objective of supporting tool	Description of step
Step 1: Ecosystem Canvas	Map the entities	Identify entities that will produce value and consume value in ecosystem. Cluster the similar actors together if they share the same goal or interaction. These actors are divided into supply and demand. The canvas layout also considers the effect of the most influential actors.
Step 2: Motivation Matrix	Investigate motivations	The matrix aims to expose why actors join in the platform. It looks at the potential to exchange within the ecosystem as well as the intrinsic motivations related to joining the platform. The diagonal of the matrix highlights essential questions to identify intrinsic motivations which the value propositions must aim to answer.
Step 3: Transaction Board	Identify value units and the channel and context of exchange	The transaction board makes a list of key transactions in terms of the interacting entities, the value unit exchanged and the channel and context in which it occurs.
Step 4: Experience Learning Canvas	Reflect on services and improvement that platform offers	This canvas focuses on designing the stepwise evolution of the participants assuming three general steps. These include onboarding, getting better and new opportunities. For each step, the canvas identifies challenges and related services provided by the platform.

As mentioned previously, the outcomes of each of the above four steps are included in the overall Platform Design Canvas in Figure 44. This canvas identifies the key elements of a platform and its stakeholders within the platform ecosystem to formulate an overarching Platform Design Canvas. This canvas is then populated by breaking down each component of the canvas and considering it separately. This toolkit, however, places a large amount of focus outside the platform and not as much focus on elements inside the actual platform architecture and platform firm itself.

The first valuable insight from this tool is its classification of key ecosystem roles into impact-related, supply-related and demand-related and subsequently clustering the roles that have similarities

together. Another key insight from this toolkit is the consideration of intrinsic motivations, which affects why participants would choose to join the platform. The intrinsic motivations of the key ecosystem roles led to important questions that should be asked during the design stages of the platform. The questions inspired by intrinsic motivations of the desired ecosystem actors should be answered by the platform's value proposition(s). The segregation of platform transactions into (1) the entities involved, (2) value unit exchanged and (3) the channel/context of the exchange, resulted in additional insights on how the value will essentially be created and captured by the platform. The layout of the toolkit in terms of its main canvas supported with numerous different tools are a practical and unique way to approach platform design.

4.8.2.4 Platform evolution: A framework for studying platform evolution

The framework for studying platform evolution [124] is not explicitly a management framework, but aims to facilitate the understanding of platform-based ecosystems and relating platform design to its evolution. The framework considers a software-based platform and its modules to form the platform's ecosystem. The idea behind the framework follows from the notion that the evolutionary dynamics of the ecosystem are affected by co-evolution of two types of decisions. Firstly, the endogenous decisions by platform owners such as architecture and governance and secondly, the exogenous environmental dynamics. This framework emphasises the focus on the developer or supply side of a platform, specifically for software-based platforms and for platforms whose multi-sidedness involves the module developer (supply side) and the end consumers (demand side). The framework is shown in Figure 45 on the next page.

The framework is fuelled by the challenges and opportunities the researcher have identified for such software platforms within Information Systems (IS) research. The six challenges identified include the change of competition, expansion of traditional firm boundaries, the evolutionary trajectories determined by technical architectures and organising principles, control and autonomy related to governance, platform robustness and the IT artefact at the core of evolution. The last aspect is of particular insight by suggesting that the IT artefact should be part of the theory development process on evolution as it can provide additional insights to those typically derived from strategy, economics and software engineering research. The challenges are translated into five research questions which are included in the framework.

The first section of the framework refers to platform design, governance and environmental dynamics. Platform architecture in this context refers to a codebase with high reusability and low variety and its modules which occur in a wide variety but with low reusability. Ideally this architecture should support variety in the present and be able to evolve in future. The architecture is viewed from three perspectives: decomposition, modularity and design rules. Decomposition refers to the way in which a platform's ecosystem is broken down into subsystems. In other words, it indicates which subsystems and functionalities are either inside or outside of the platform codebase. Modularity refers to the extent to which changes in a subsystem will affect another part of the ecosystem. Modularity entails a balance between unnecessary costs and facilitation of innovation. Design rules are the rules set by the platform owners which users of the platform should conform to. These design rules should be stable, but not constrain innovations within the ecosystem.

The next section of the framework refers to the platform governance, referring to who decides what with regard to the platform. Governance can also be viewed from three different perspectives including decision rights partitioning, control and proprietary versus shared ownership. Decision rights refer to the division of decision-making authority within the ecosystem. The second perspective includes formal and informal control mechanisms implemented by the platform owner to maintain specific behaviours. The final governance perspective is whether the platform is proprietary to one firm or shared by many firms.

The framework also highlights the environmental dynamics of the platform ecosystem where it focuses on three concepts. The first concept for consideration is that of technological convergence. Technological trajectories such as the rapid emergence of new technologies can affect platform evolution. These new technologies could create opportunities for the platform to expand into other domains but also encourage adjacent platforms to expand in unwanted domains. This may result in overlapping user bases. Secondly, the framework includes multihoming costs. This refers to the costs incurred by developers for joining more than one platform. The final element includes the influence exerted by complementors. This specifically refers to players such as service suppliers (for example Warner Brothers' services to Netflix) and regulatory authorities which may have divergent interests from those of the platform owner, resulting in tensions and affecting platform evolution. The framework also suggests that the interactions between platform architecture and governance, as well as the interactions between the environmental dynamics with the platform, may influence the evolutionary dynamics.

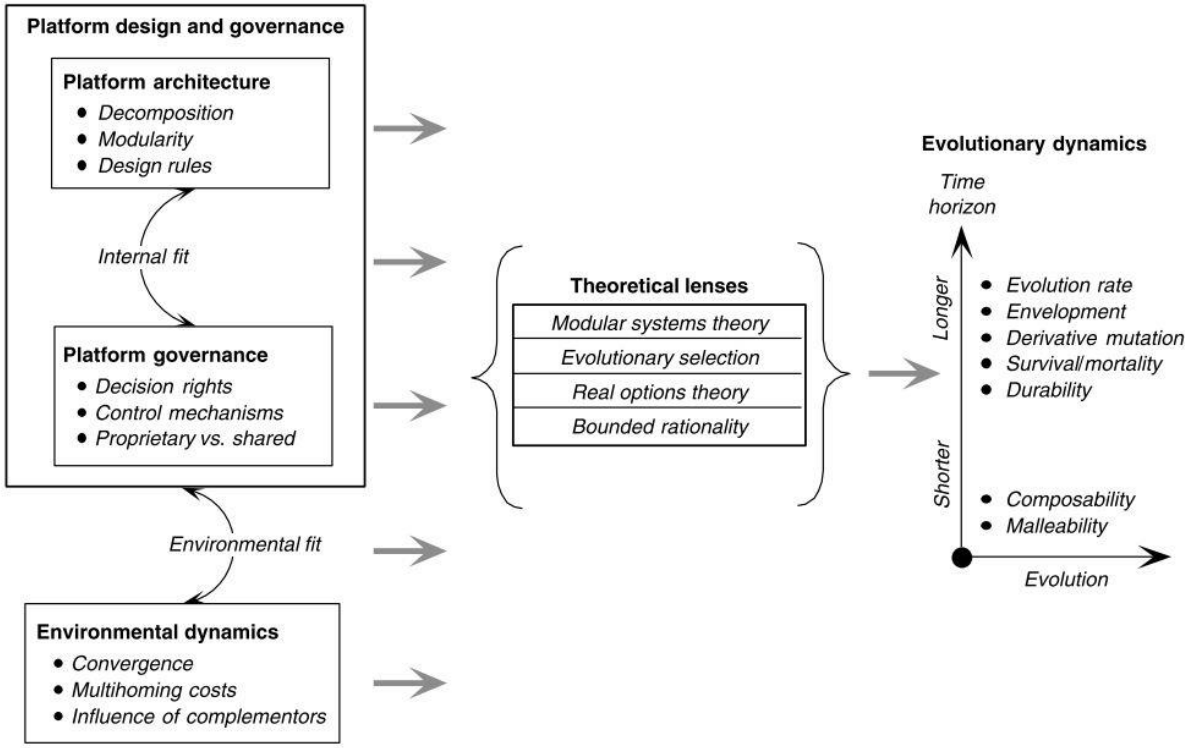


Figure 45: Framework for platform evolution research [124]

Four theoretical lenses which could be adopted for research within this area are also presented. These are Modular Systems theory, Evolutionary selection, Real Options theory and Bounded reality and are not a part of the scope of this research. As a final part of the framework, five long-term and two short-term evolutionary dynamics criteria are suggested. The long-term criteria include evolution rate, envelopment, derivative mutation, survival and durability. The short-term criteria include composability and malleability. The details of these evolutionary dynamics criteria are also outside the scope of this research. It can, however, be seen that it relates to previously mentioned ecosystem literature which draws from natural ecosystems

The framework suggests that platform architecture and governance not only affect evolution, but also each other. Additional insights include that the endogenous factors of the platform should co-evolve with the ecosystem and that the concepts of modularity, openness and design rules all require a balancing act by platform owner. This correlates with the Platform Owner's balancing act in Section 4.5. An important distinction between formal and informal control mechanisms was also made, substantiating previous literature on platform control. Although beyond the scope of this project, the

evolution criteria included can be considered during platform design stages in order to better design for evolution.

4.8.2.5 Open software enterprise model

The open software enterprise model [152] presents numerous different openness options that should be considered by a software-producing organisation (SPO) in terms of how open or closed it should be. This is a major issue for contemplation, especially for platforms where the boundaries regarding openness for third-party innovators should be established. Therefore the aim of this model is to establish how open or closed an SPO is. This is achieved by considering each of the openness options presented in the framework and relating it to the SPO. The openness options are presented in the form of actionable phrases, making it easy to know where to enhance or reduce openness. The open software enterprise model is shown in Figure 46.

	Governance	Research and Development	Software Product Management	Marketing and Sales	Consulting and Support Services
Strategic	- Open up governance - Create partnership model - Open up IP strategy - Coordinate contributions to other ecosystems - Share competition policy - Share acquisition strategy - Implement ecosystem knowledge mgmt strategy	- Share technology and research roadmap - Share development process knowledge - Stimulate open standards - Share source code - Apply for joint research and development funding	- Share product lifecycle plans for products - Share platform strategy and vision	- Share market vision - Develop innovative business models - Create sales partner program	- Share services delivery management strategy
Tactical	- Enforce development process standard - Provide partners with governance procedures - Coordinate grievances - Help partners in IP conflicts	- Share innovations - Support interchangeable data formats - Share source code policy - Create reuse policy - Outsource tasks - Certify third-party components	- Outsource requirements engineering to partners - Share and adjust product (line) roadmap(s) - Manage third party IP in product	- Share market information - Share customer and supplier information - Develop distribution channels	- Outsource implementation projects to partners - Share ticket database - Share project process knowledge - Develop and share quality measures
Operational	- Make ecosystem explicit - Create a partner directory - Create user groups - Use and create reusable software licenses	- Create and publish (content) APIs and SDKs - Create reuse enabling architecture - Open up testing process - Share bug repository - Do co-development - Provide developer training - Propagate software operation knowledge	- Open up requirements management process - Open up release planning process - Share release candidates	- Certify partners - Create internal and external component markets - Involve partners in marketing and sales	- Share implementation knowledge - Share (customer) configuration knowledge - Use collaborative workspaces for customer communication - Provide consultant training

Figure 46: The Open Software Enterprise Model [152]

The model comprises two dimensions: a management dimension and a SPO practices dimension. The management level is further decomposed into three levels, namely the strategic, tactical and operational levels of the SPO. The five SPO practices dimensions were derived from existing product software and SPO business process models. These dimensions include governance, research and development, software product management, marketing and sales, and consulting and support services. Governance refers to the managing of the SPO and includes decision-making powers and responsibilities. Software Product Management (SPM) refers to managing the software built and considers the product life cycle. The research upon which the model is built also assumes that an SPO will provide consulting and support to aid in customer set-up or product deployment.

This model yielded insight not only into openness, but also into an SPO and its core business processes. The decomposition of management into further levels also proved a useful manner to move from a macro level to micro level of detail within the model. The model also indirectly incorporated the role of the technology provider as the keystone player within its ecosystem and its effect on the overall ecosystem health. This featured strongly within the governance dimension. The model therefore highlights the multidimensional nature of openness which subsequently not only refers to the architecture itself, but also to other processes within the software producing organisation.

There were a number of conclusions that could be drawn from this model. The classification of five dimensions that affect openness are key for future research, it is clear that openness goes beyond just the platform architecture. Numerous key concepts in terms of openness are now exposed and can be valuable for the proposed framework. The model also clearly portrayed the relation between traditional product core business processes and those required for software product core business processes which could be an interesting approach to view a software platform firm.

4.8.2.6 Boundary resources model

This Boundary Resource Model [15] aims to assist a platform owner in boundary resource design and understanding for third-party development. Software platforms in this context refer to the software codebase providing the core functionality and interfaces through which it interacts with modules. The model builds on the fact that third-party development is enabled by shifting design capabilities from the platform firm to the external actors who in turn meet the needs of end users through developing applications. Boundary resources are seen as the software tools and regulations at the interface between the platform owner and developers. The model, shown in Figure 47, adds to the Information Systems (IS) field and builds on process theory.

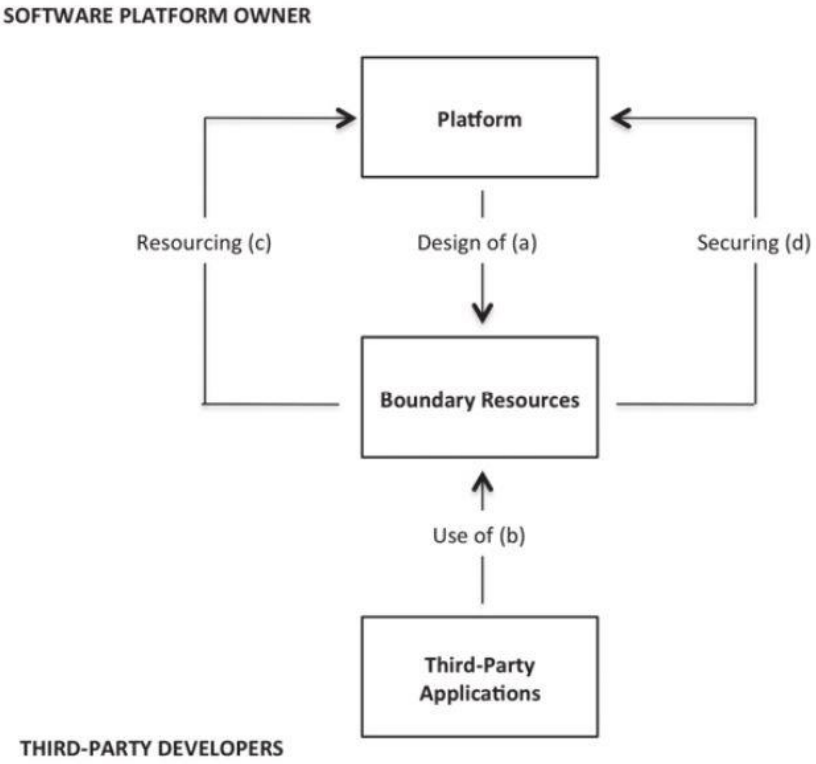


Figure 47: The Boundary Resources Design Model [15]

Boundary resource design includes the development and modification of boundary resources as a result of external contributions and control concerns. An example would be the use of APIs as the interface between the platform and applications developed by third party developers in order to serve end users. These boundary resources may be designed for two reasons, namely to enable the developer community to extend the platform or based on control concerns. Therefore, boundary resources are what allow new resources to be added to the platform and subsequently result in the process of resourcing. Resourcing is the process whereby the platform scope and diversity are enriched. The boundary resources are key for heterogeneity where each participant may pursue their own interests. As a result, the platform owner may have to implement more control which can also be enforced by the boundary resources. Securing therefore forms a key part of the model and refers to the increase of platform control. The model suggests that resourcing and securing are the two drivers

for boundary resource design and they are both vital in managing a platform ecosystem despite the inherent tension between them.

The research behind this model clarified the definitions, roles and challenges associated with boundary resources. The model also yielded insight into the two vital roles of boundary resources: (1) enabling third-party developers to innovate and build new products and services using the platform and (2) the use of boundary resources to secure and control the platform.

4.8.2.7 Analysis

By analysing the FMTs on platform design and management collectively, it could be observed that several elements surfaced in more than one of the FMTs. These elements were therefore highlighted for further consideration in the final framework developed in this research. The first two conclusions were regarding a platform and its environment. The importance of establishing both the internal and external environments of the platform ecosystem were clear. Many FMTs complemented the identification of desired ecosystem actors by clearly defining each actor's role and desired platform value propositions. Several of the FMTs also included practical elements that provided additional insight into how to implement or approach those elements. A practical element that featured throughout the FMTs was that of naming a concept and supplementing the concept with questions. A reason for this might be to provoke thought, but also to emphasise the fact that each platform will differ and therefore one correct answer may not be possible. FMT 5 and FMT 6 (see Table 35) specifically focused on elements at the interface and external to the platform and therefore highlighted aspects that would most likely have to be considered regarding third-party developers.

General comments include that the FMTs with practical elements, or that had a more organised approach and layout such as those with canvasses had a more significant impact. Therefore layout and structure are also key elements to consider when designing a useful FMT.

A visual analysis of the frameworks is included in Table 35, included on the next page. The elements by which the frameworks were analysed included general elements and criteria-related elements. The criteria-related elements specifically relate to the criteria derived previously. General criteria included clarifying whether the FMT is a framework, model or tool, its platform perspective is, the general layout of the FMTs and relevant research areas. For more information regarding the criteria-related elements, please refer to Section 4.8.1.

Six different FMTs relating to platform design and management were therefore investigated and analysed. Subsequently, the researcher gathered key insights into the further development of the framework. The following section of FMTs investigated and analysed were those relating specifically to ecosystem literature.

Table 35: Linking the FMTs to the Stage 2 and Stage 3 criteria

		FMT1	FMT2	FMT3	FMT4	FMT5	FMT6
General information	Framework or model, tool	Framework	Toolset	Model	Framework	Model	Model
	Type of platform	Both	Market	Market	Both	Innovation	Innovation
	Layout	Table, no order	Canvasses, flow from one canvas to another	Canvasses, sub-tools, steps	Diagram	Matrix	Process
	Research area	Design Science	Business model	Platform strategy	Information systems (IS)	IS using design science	IS
Criteria	Platform design	✓	✓	✓	✓		✓
	Management aspects	✓	✓	✓	✓	✓	
	Maturity/ evolution/LC	✓		✓	✓	✓	
	Ecosystem	✓	✓	✓	✓	✓	
	External environment	✓	✓				
	Value creation	✓	✓	✓			
	Governance	✓			✓	✓	
	Architecture	✓	✓		✓		✓
	User-focused		✓	✓	✓		✓
	Competition	✓	✓				
	Openness	✓			✓	✓	✓
	Control				✓	✓	✓
	Entry barriers			✓	✓		✓
	Pricing/ revenue model	✓	✓	✓			
	Ecosystem health				✓		
	Actor roles	✓	✓	✓			
	Design rules				✓		
	Practical elements	✓	✓	✓		✓	

4.8.3 Ecosystem perspective

The FMTs included in this section focus mainly on the ecosystem formed around the platform. The identified FMTs include the framework for ecosystem governance [155], the governance model for ecosystem health preservation and improvement [116] and the software ecosystem strategy assessment model [154]. Each FMT will be briefly discussed, followed by its main highlights. Subsequent to discussing all the FMTs, an analysis will discussed.

4.8.3.1 Framework for software ecosystem governance

The software ecosystem (SECO) governance framework can be used by SPOs for strategic advantage and improved ecosystem health and performance. The framework builds on the definition of a SECO as defined by Baars and Jansen [155]. The framework makes a clear distinction between governance and a governance structure. Governance refers to the procedures and processes used to manage the current and future position of a company in a SECO. Governance structure includes the rights, responsibilities, rules and protocols related to the stakeholders and decision-making of the SECO.

Therefore, the framework comprises two segments: a governance segment focusing on processes and procedures and a governance structure segment focusing on control, responsibility and measurement. The Governance segment has seven categories, namely partnerships, supplier and customer governance, development, partner directory, customer directory, user groups and licence(s). Each of these categories has one or more related SECO governance concept to which a company can answer either yes or no. The governance structure segment comprises five categories, each with one or more related governance structure concepts which are formulated as questions. The first category refers to ecosystem explicitness. The relating questions aim to formulate an explicit governance strategy. Governance explicitness is the second category which aims to establish whether formalised documents, processes or procedures exist. Thirdly, the framework includes a responsibility category which clarifies the decision-making procedures and units. The fourth category refers to measurement aspects including KPIs, goals and effectiveness. The fifth and final category aims to establish whether knowledge sharing takes place within the ecosystem.

The segmentation of this framework into governance and governance strategy illustrates a unique way of approaching ecosystem governance. Particularly the governance strategy segment and its corresponding categories provide valuable information. It emphases the clarification of responsibility within the ecosystem for the governance strategy. It also illustrates examples of measurement methods within the ecosystem and indirectly refers to the openness or availability of knowledge within the ecosystem. The framework is structured in a practical way by translating the main categories into related sub-concepts and questions to provoke thought.

4.8.3.2 Governance model for ecosystem health preservation and improvement

The overarching aim of this governance model [116] is to aid in formulating strategies for maintenance and improvement of SECO health. Software ecosystems are seen as comprising organisations connected through software or a concept that is related to software, and are subsets of business ecosystems. This model also views the customers as a part of the software ecosystem. Software platforms are viewed as fulfilling a key role within such a software ecosystem. The platform definition adopted in this research states that a platform is a "*foundation technology or set of components used beyond a single firm that brings multiple parties together for a common purpose or to solve a common problem*" [137]. SECO governance therefore includes the procedures and processes enabling a company to control, change or maintain its present and desired future states within the ecosystem. The governance model can be used by platform owners to establish whether the correct methods of ecosystem governance are being used to best reach its strategic goals.

The governance model, shown in Figure 48, has two dimensions, namely ecosystem health components and ecosystem coordinator types. The ecosystem health components include robustness, niche creation and productivity as initially suggested by Iansisti and Levien [12]. Each of these aspects is linked to corresponding governance tools, depending on the coordinator type. The coordinator dimension of the model comprises two main categories: software service platform and standard. Each of these categories is also subcategorised into a community owned or privately owned entity. The software standards category does not represent a software platform, but the standardised interfaces enabling communication and information exchange. The core of the standards ecosystem, shown on the right in Figure 48, is knowledge, not a software platform. Therefore this category is outside the scope of this research.

	Software (service) platform		Standard	
	Community	Private Entity	Community	Private Entity
Niche creation	Expand applicability Make strategy explicit Create APIs Do co-development Contrib to comp. platforms	Expand applicability Make strategy explicit Create APIs Do co-development Dev. complementary platforms Develop new business models	Expand applicability Make strategy explicit Form subgroups	Expand applicability Make strategy explicit Form subgroups
Robustness	Form consortium Grow consortium Create subgroups Raise entry barriers Form alliances Stabilize APIs Make consortium explicit Open up governance	Create partnership model Do marketing Grow profits Partner development programs Form alliances Stabilize APIs Raise entry barriers Make partners explicit Propagate operation knowledge	Form consortium Grow consortium Raise memberships Form alliances Make consortium explicit Open up governance Start certification program	Protect the standard legally Do marketing Raise memberships Evolve platform Make partners explicit Start certification program
Productivity	Organize dev days Create knowledge hubs Participate in contests	Organize dev days Collaborative marketing Create sales partner program Create new sales channels	Create showcases Create knowledge hubs	Create showcases Collaborative marketing Create new sales channels

Figure 48: The Governance model for ecosystem health preservation and improvement [116]

The model suggests that the way in which the ecosystem is governed is affected by its ownership and the nature of its coordinators. The success of the governance and therefore the health of the ecosystem can also be related back to three primary health metrics: niche creation, robustness and productivity. It can also be concluded that despite the differences between a community-based platform and a private entity, many of the concepts to consider for ecosystem health remain the same. The importance of boundary resources such as APIs and the role of entry barriers in ecosystem functioning is illustrated.

4.8.3.3 Software ecosystem strategy assessment model (SECO-SAM)

The main purpose of the SECO-SAM [154] is to define key characteristics of a SECO. The SECO-SAM is developed with the assumption that a SECO health can be influenced in the same way that a person's health is influenced. The influential aspects are based on health sector literature and include biology, lifestyle, environment and healthcare organisation. The model is arranged as a hierarchical tree with each of these health influencers as a top-level concept. The ecosystem strategy is viewed as an extension of the platform strategy. The research behind the model also distinguishes between product and platform strategy. The SECO-SAM can be seen in Figure 49 and should be viewed from the platform owner's perspective.

The first branch of the SECO-SAM refers to SECO biology which is segmented into its composition and its health. Composition refers to the hub, niche players, platform and the relationships within that ecosystem. The health metrics of the SECO include productivity, robustness and niche creation. The second branch is the lifestyle of the SECO and it is broken down into a strategic level, tactical level and operational level which are all used for decision-making within the SECO. The strategic level has four key characteristics of which the first characteristic refers to the SECO vision. The SECO vision plays an important role to niche players in that it allows them to see what the SECO's desired future state is and may encourage or discourage a niche player to join the SECO. The second characteristic is the platform strategy. While product strategy is driven by corporate strategy and vision, SECO vision is the core of the platform strategy. Thirdly, stability is encouraged with regard to the SECO strategy and vision as it aids in direction for niche players. The final characteristic on the strategic level is reputation management. This is linked to its ability to attract stakeholders, develop relationships and ultimately SECO success.

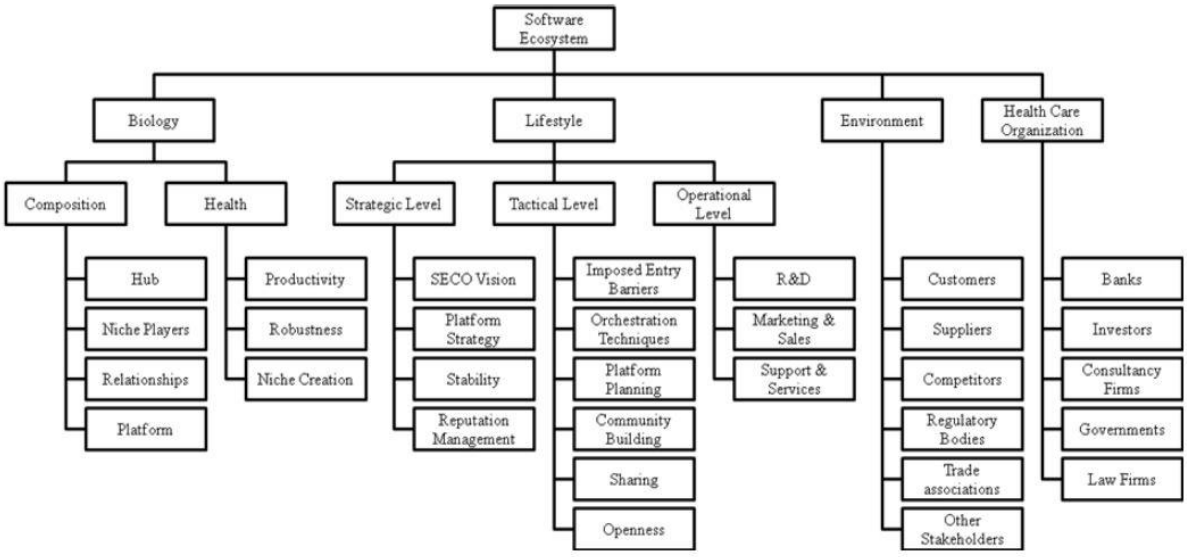


Figure 49: The SECO-SAM [154]

The tactical level of the model comprises six characteristics: (1) imposed entry barriers (2) orchestration techniques (3) platform planning (4) community building (5) sharing and (6) openness. The entry barriers are key to filter the firms that join the ecosystem and to maintain control over the quality of the ecosystem. The management of the ecosystem actors and networks are classified as the SECO's orchestration techniques. Community building is directly related to robustness and therefore ecosystem health. This refers to the keystone's firm intervention in building the connections between niche players. The keystone must also facilitate knowledge sharing within the ecosystem for increased innovation and production. The final characteristic, openness, is divided into three categories: open standards, open formats and open source. The platform owner should choose the levels of openness for each while considering the subsequent effect on ecosystem health.

The third level consists of three subcategories, namely research and development (R&D), marketing and sales and support and services. Within a SECO, the R&D can be conducted by the platform owner alone or by collaborating with the niche players. Marketing and sales play an important role for the keystone firm as well as the niche players, as all actors will be affected if the platform is not marketed adequately. Niche players will also require support and services with regard to the use of the platform.

The third branch of the model refers to the SECO environment, over which it has little control. The environment consists of customers, suppliers, competitors, regulatory bodies, trade association and other stakeholders. The final branch is healthcare organisation which refers to the means at disposal

by which SECO health can be improved. This branch is divided into banks, investors, consultancy firms, governments and law firms.

There were several aspects that stood out from this model. The link between ecosystem health and human health is a unique perspective adopted in this model. The distinction between the organisational level (which entails the platform vision) and the ecosystem level (which entails the SECO vision) was also insightful. Similarities to other FMTs in this section include the use of productivity, robustness and niche creation as ecosystem health indicators. Another aspect that stood out is the repetition of the strategic, tactical and operational level (three basic decision-making levels) classification of the SECO. The platform vision should be developed with the SECO vision in mind. Also, the different types of openness that are considered in this model motivate to look beyond architectural interfaces when considering openness. A key insight that this model yielded was that each of the included components can be related to ecosystem health. The researchers also mention that all the included elements might have different weighting factors. This led to the insight that the proposed framework of this research could possibly investigate the differences in impact of included concepts.

4.8.3.4 Analysis

The FMTs discussed in the ecosystem section were analysed separately and collectively. One component that stood out was the importance of being aware of the entry barriers that relate to both the platform and the platform ecosystem. The ecosystem perspective FMTs also established the role of a platform as the centre and foundation of a SECO, and a platform owner cannot define a vision for the SECO without starting at the platform level. It was also clear that ecosystem health is regarded as a key component to consider as orchestrator of the ecosystem and the ecosystem health metrics (productivity, robustness and niche creation) are widely used as the basis to determine ecosystem health. Similarly, as with the FMT analysis for platform design and management, Table 36 indicates how well the ecosystem perspective FMTs meet the criteria. It also indicates general information regarding the platforms.

Table 36: Linking the FMTs to the Stage 2 and Stage 3 criteria

		FMT1	FMT2	FMT3
General information	Framework, model or tool	Framework	Model	Model
	Type of platform	Innovation	Innovation	Innovation
	Layout	Segmented table	Matrix	Hierarchical tree
	Related research	IS, ecosystem governance	IS, Ecosystem health	IS, Ecosystem strategy
Criteria	Platform design		✓	✓
	Management aspects	✓	✓	✓
	Maturity/ evolution/LC			
	Value creation			
	Governance	✓	✓	
	Competition			✓
	Openness		✓	✓
	Entry barriers	✓	✓	✓
	Questions	✓		
	Ecosystem health	✓		✓
	Actor roles	✓		✓
	Design rules		✓	
	Practical elements		✓	

Following the investigation and analysis of the FMTs relating to ecosystems, the researcher had a better understanding of what a framework should entail and gained further insight into the design and governance of a platform ecosystem.

4.9 Chapter 4 summary

Chapter four formed the conceptual literature review and included five main areas of review: (1) platform ecosystems, (2) technology platforms and their key characteristics, (3) the challenges faced by platform owners, (4) platform ecosystem dynamics, including the South African health context and (5) the need for management tools and the investigation and analysis of existing FMTs.

The vast amount of literature obtained from the systematic literature review, conceptual literature review and the existing framework, models and tools investigation, combined with the growing understanding of the ecosystem dynamics resulted in the formulation of an inventory framework (also referred to as preliminary framework). The inventory framework is introduced in the next chapter.

Chapter 5: Framework evolution Part 1: Inventory framework

Chapter 5 key objectives:

- Present the first stage of the framework evolution, namely the inventory framework
- Discuss each of the three levels of the inventory framework
- Discuss the ecosystem dynamics between the three levels

5.1 Introduction

Chapter 5 introduces the inventory framework. The inventory framework formed the basis of the development process for the final framework for the design, development and implementation of technology platforms in the South African health context. The inventory framework focused on integrating and grouping together the concepts identified previously as suggested by Jabareen [39]. The concepts were integrated into a framework comprising an inventory of concepts to consider at each level of the platform ecosystem. The framework is to be interpreted from the perspective of a platform owner. The inventory framework formed the final part of Part 2 of the Research Design as shown in Figure 50. Certain sections of this chapter formed part of an article submitted to and presented at the International Association of Management of Technology (IAMOT) 2018 conference in Birmingham, United Kingdom [201].

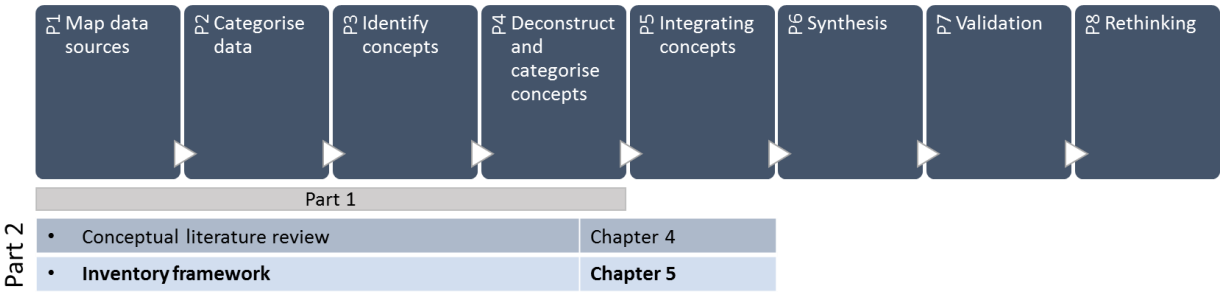


Figure 50: Document context diagram: Chapter 5

The framework evolution can be categorised into four categories: (1) inventory framework, (2) preliminary framework evaluation (following the MomConnect investigation), (3) evaluated and adapted framework (following the interviews) and (4) towards a final management tool (following the case study). This evolutionary nature of the framework as well as the alignment with the progressive evaluation process and relevant chapters are indicated in Figure 51. The context of this chapter is indicated by the darkened and dashed block in Figure 51.

The aim of the inventory framework was to provide an inventory of relevant concepts regarding the three ecosystem actors which can be further used in developing the final framework. The concepts draw from diverse areas such as business strategy [137], software engineering [157], [194] innovation management [80], [85] social science [128], software ecosystems [132] and business ecosystems [12], [131], [133]. It should be mentioned that some concepts were broad and could potentially be researched further. Also, some of the included concepts somewhat overlap. The inventory framework included concepts drawing from both the ecosystem and engineering views as its focus was on integrated platforms. As the exact scope of each platform varies (internal vs external platform for example), all included concepts may not always be applicable for every platform owner. The inventory framework is discussed in this chapter on an actor level as well as on an ecosystem level.

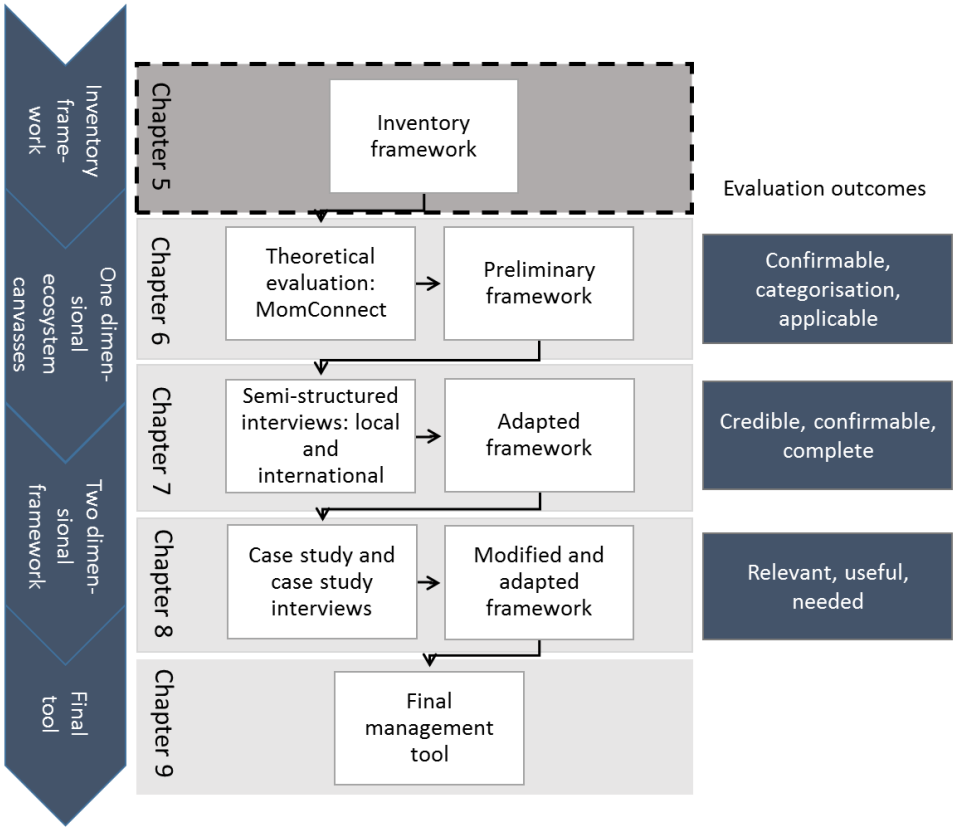


Figure 51: Framework evolution and evaluation processes

The inventory framework can be approached by asking the following questions for each framework level (with each level corresponding to an ecosystem actor):

I. Platform owner level: What should the platform owner consider with regards to its own firm and the software platform?

II. Developer level: What should the platform owner consider with regards to the developers using the platform?

III. End-user level: What should the platform owner be aware of and apply to its platform to enhance the development and uptake of end-user products and services?

A visual representation of the framework and its three levels are shown in Figure 52 on the next page. Some of the concepts included in each level are also illustrated within the figure.

5.2 Actor level: Platform owner

The first level of the inventory framework considers the platform owner. This level comprises five categories: (1) strategy, (2) architecture, (3) governance structure, (4) internal organisation and (5) operations. It should be noted that the technology platform itself is classified within the platform owner level of the framework, seeing as the platform owner is responsible for designing, developing and maintaining the technology platform. The platform owner level is shown in Figure 53 on page 91.

The strategy category refers to the guiding principles and important decision-making factors related to the platform owner and its software platform. The platform owner should explicitly define its scope in terms of its desired ecosystem participants, the core interaction of the platform, the platform openness, the complete software delivery model and also what is excluded from the ecosystem scope. The concepts related to the software of the platform were categorised within the architecture category. As described previously, the stability, scalability and modularity of a software platform are significant factors as complementary products and services will be developed on top of the platform.

These development processes are enabled by the platform interfaces. The control over the interfaces is linked to the control of the platform and platform evolution [109]. An overview of the platform owner level of the inventory framework is shown in Figure 54 on the following page.

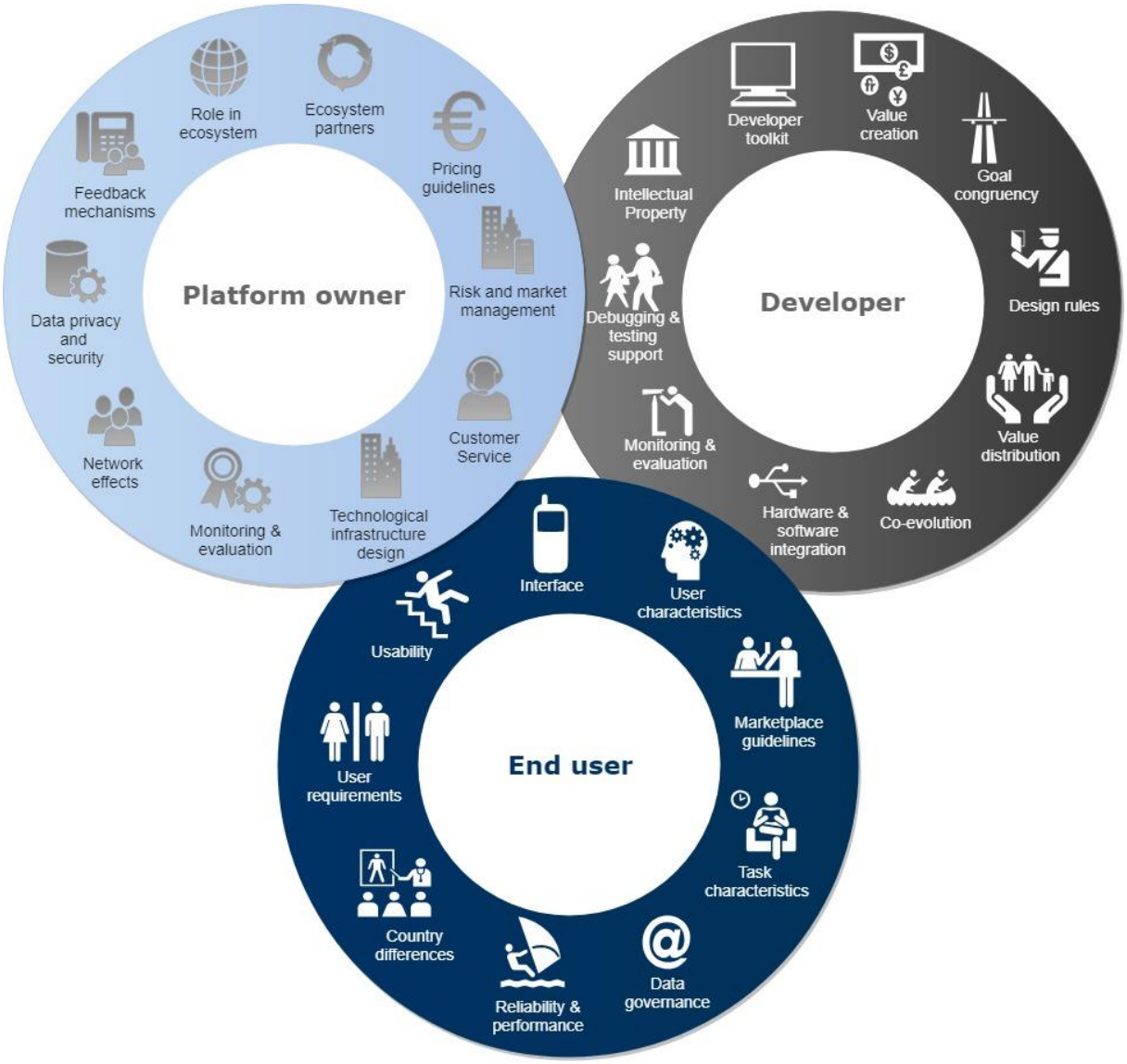


Figure 52: Visual representation of the three levels of the inventory framework, including some concepts

The second category is the governance structure of the platform firm which refers to the distribution of rights and the rules and protocols within the ecosystem. This includes the development of licencing agreements, the decisions regarding ownership of the platform and the decision rights amongst the ecosystem participants. As the keystone within the ecosystem, both external and internal ecosystem parties will look to the platform owner as an indication of the ecosystem health. Therefore, the internal organisation section includes the generation and implementation of corporate values, beliefs and culture to promote a healthy firm and ecosystem.

The operations category refers to the aspects related to the smooth functioning of the platform firm and its ecosystem – again motivated by the perceptions of the keystone firm reflecting the health of the ecosystem. Especially in the information technology (IT) industry, the rate of new emerging technologies requires constant research and development (R&D) efforts. The platform owner should involve the complete ecosystem and monitor competing ecosystems. An effective marketing and sales approach could encourage the growth of the ecosystem. Gawer and Cusumano [143] place market

management as one of three foundations of ecosystem competition. In order for the platform to continuously improve and evolve, the platform owner should look for new opportunities with regards to its scope and ecosystem participants which Ghazawneh and Henfridsson [15] refer to as resourcing. Some risks may need to be taken in order to evolve the ecosystem. The platform owner can share the intentional risks (monetary investments or adjusting scope, for example) within the ecosystem [79]. To minimise the unintentional risks, the owner should continuously adjust the control strategy across the ecosystem. The next level of the inventory framework relates to the developers.

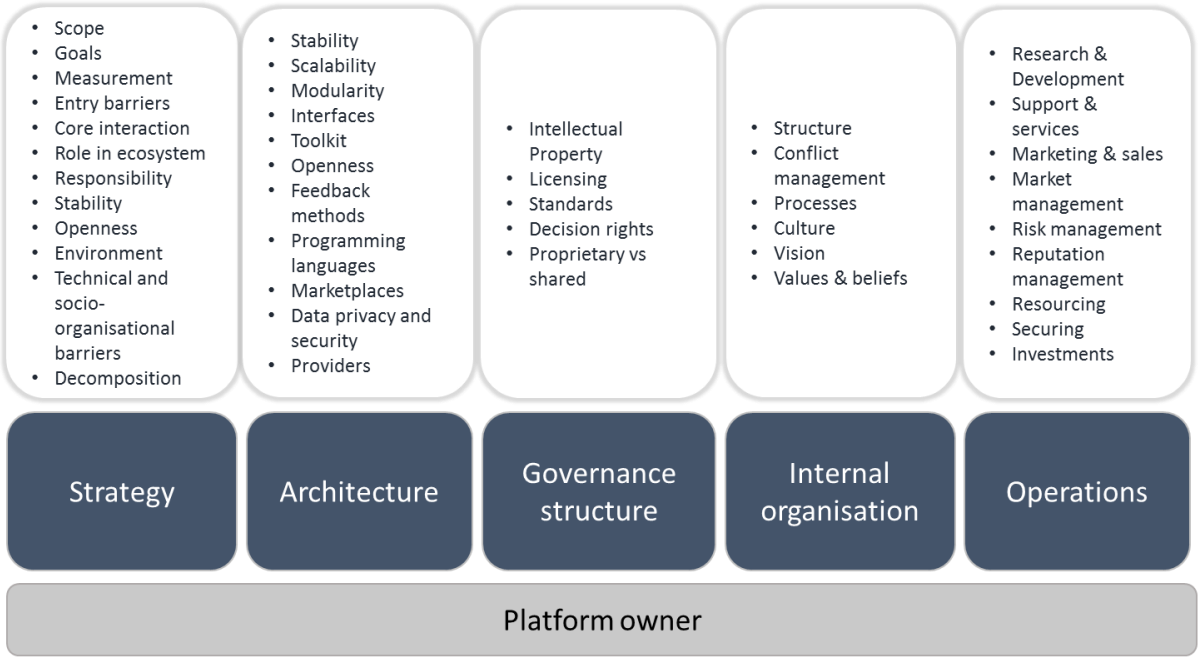


Figure 53: Inventory framework: Platform owner level

5.3 Actor level: Developer

The second level of the inventory framework, shown in Figure 54, presents the concepts that the platform owner should consider regarding the developers using their platform. The main categories for this level include the entry barriers, the governance structure, the ecosystem-related concepts, the concepts related to the platform software architecture, standards and current models that could be helpful, the different customer support concepts and the control that the platform owner should consider.

The first category includes the entry barriers of the platform and its ecosystem. These can be related to both the platform firm itself as well as to the software platform and its architecture. As with the first framework level, the governance structure category refers to the distribution of rights and the rules and protocols within the ecosystem, specifically with regard to the developers, their products and services and the platform-related rules. The ecosystem-related concepts refer to the elements that involve more than one ecosystem actor and the relationships between the developers and the platform firm. The software architecture category includes specific concepts that the platform firm should be aware of regarding the use of their platform and its interfaces. During the reading of the level-specific literature, specific standards and models featured that could provide guidelines for the platform owners in terms of openness decisions and partnerships with other ecosystem participants.

As the developers might not be aware of the internal functioning of the platform, the platform owner should provide sufficient support and testing components to enable developers to successfully use their platform. It might also be required that the platform owner personally engage with the developers. The last category within the developer level of the inventory framework relates to control

aspects the platform owner should administer. Subsequent to the developer level, the third level refers to the end users of the products, services and technologies developed using the platform.

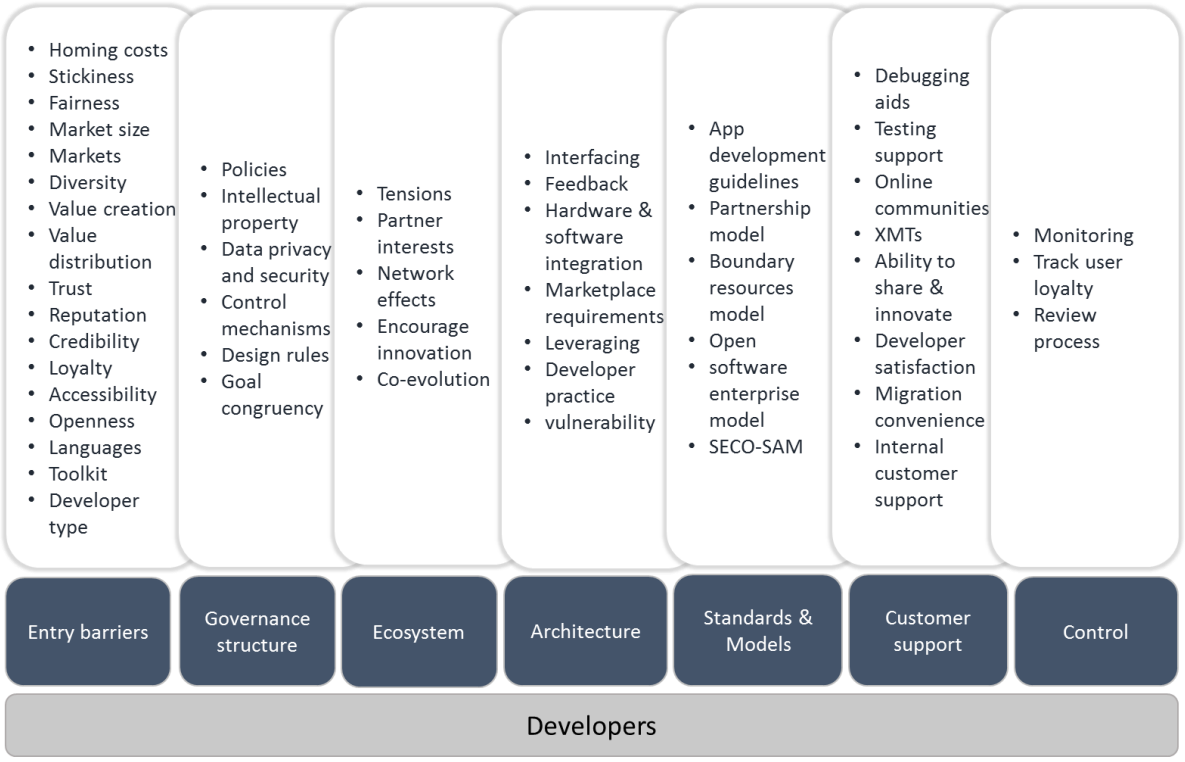


Figure 54: Inventory framework: Developer level

5.4 Actor level: End user

The third level of the inventory framework includes the concepts related to the end users. Figure 55 presents this level of the framework. The interpretation of this level depends on whether the platform firm functions as an internal or external platform firm. The overarching categories include the context of use of the product or service, measures of quality control, feedback mechanisms, standards and models that can aid in app development and other attractiveness-related aspects.

The developer should be aware of the context of use of the end product, service or technology developed on the platform. The context not only refers to the physical or social contexts, but also to the geographical context (related to network strength availability) and countries of use (laws and regulations may differ). Certain measures of quality control could be established, as the platform owner is indirectly affected by the success of the end-product. The ecosystem is dynamic and should continuously evolve, therefore user feedback can be incorporated for app and platform updates. Especially for the design and development of apps, numerous user interface and usability guidelines exist and are included within the standards & models category for reference. As mentioned previously, the motivations regarding end users' adoption of products and services are important as they give firms a competitive edge and also spur on network effects.

At the end-user level, literature supports the need for more research and investigation into healthcare. This includes adopting usability models in the design process, looking into the attractiveness and learnability of the mHealth applications and long-term evaluation of usability methods [160]. "*Usability is one of the main barriers to the adoption of mHealth systems, principally in the case of users with special needs, like older adults or children*" [160, p. 12].

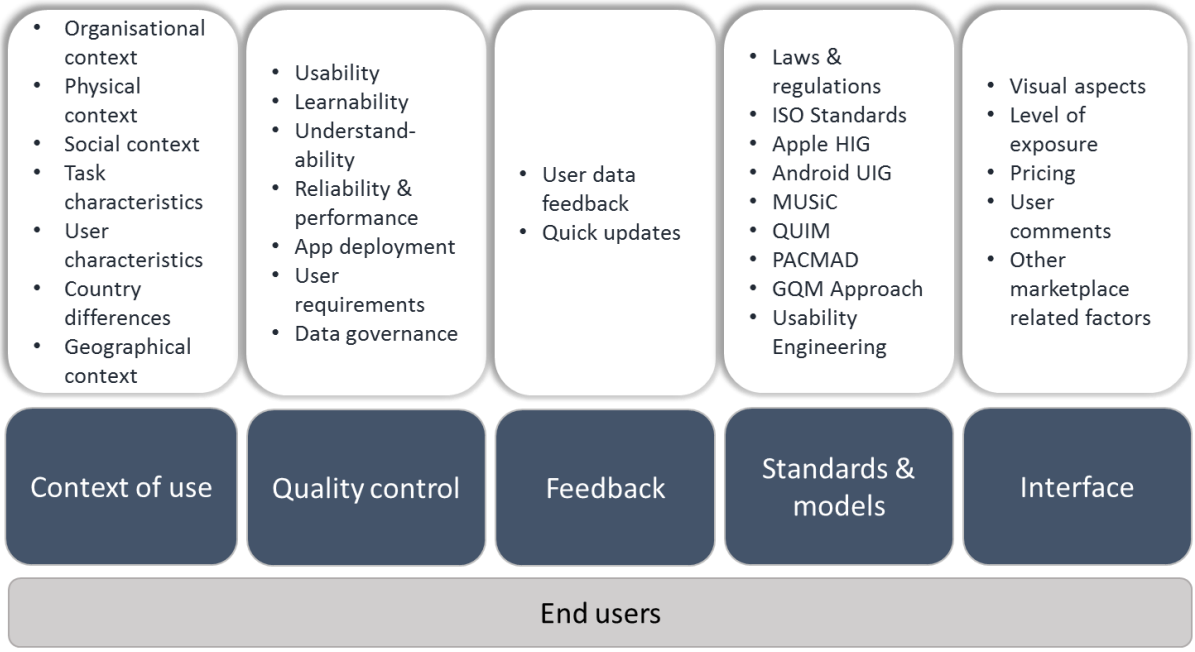


Figure 55: Inventory framework: End-user level

The three inventory levels provide specific aspects that a platform owner should consider in the design, development and implementation of its platform. The motivations for a platform owner to invest into understanding these concepts can be summarised as follows: (1) external firms look to the platform owner as a representation of the ecosystem and the firm's perceived success and health are therefore motivating aspects for others to join the ecosystem, (2) important strategy and architecture related decisions will eventually translate into ecosystem entry barriers, (3) the platform owner carries the leading responsibility within the ecosystem and if explicit boundaries, strategy, vision and scope aspects are not established, the evolution of the ecosystem could be in an uncertain direction. Therefore, in addition to the three ecosystem actors, the platform owner should also specifically look at the platform ecosystem level.

5.5 Ecosystem level: Health and operation

Proper management of SECOs can lead to better use of resources, lowering risks, helping a company reach its goals and ultimately result in an increase in revenue [198]. Baars and Jansen [198] also encourage more research similar to their governance framework with the aim of developing established theorems for an organisation's ecosystem governance strategy. As the three-level inventory framework is developed from an ecosystem perspective, it should be related to managing the ecosystem and maintaining its health. Ecosystem health can be defined simplistically as longevity and propensity for growth [132]. Within their ecosystems, platforms also have the ability to shift value from the firm level to the network level as value is co-created by all actors in the ecosystem which substantiates the need to look beyond the firm level to the ecosystem level.

Scholten and Scholten [80] found it crucial for the platform owner to perceive the platform and its ecosystem as well as its evolution as a prerequisite for internal and external innovation. They define innovation management in platform businesses as "*an ongoing process that (a) systematically identifies, evaluates and defines the strategic innovation goals of platform and ecosystem evolution; (b) implements innovation strategy both within the company and within the platform ecosystem, and finally monitors and controls strategy implementation*" [80, p. 175]. This definition substantiates the idea to link the framework to ecosystem evaluation as well as exploring the nature and drivers of its evolution.

Ecosystem health metrics have been proposed in literature [3], [12], [132], [134]. Metrics can be useful in steering the ecosystem evolution, highlight more important opportunities to pursue and to manage inevitable trade-offs along the ecosystem evolution trajectory [3]. Many literature sources classify the ecosystem health metrics in terms of robustness, niche creation and productivity. In their governance model for ecosystem health preservation and improvement, Jansen and Cusumano [116], base their model on these three health characteristics proposed by Iansiti and Levien [12]. Tiwana [3] follows a different approach by adopting three different lenses for ecosystem health metrics: (1) short-term, (2) medium-term and (3) long-term metrics. He goes on to categorise these metrics into operational and strategic metrics. The short-term metrics include resilience, scalability and composability. The long-term metrics are stickiness, platform synergy and plasticity. The long-term metrics are envelopment, durability and mutation.

The challenge with such metrics is the availability of data and the costs associated with obtaining the data. Although ecosystem health metrics are a key component in managing such an ecosystem, in-depth investigation and understanding of ecosystem health metrics are beyond the scope of this research. It is therefore a possible avenue for future research.

5.6 Chapter 5 summary

The inventory framework was included and discussed in this chapter. Each of the three ecosystem levels of the framework were discussed and the key concepts from the literature reviews highlighted. The inventory framework was presented on ecosystem actor levels and on the ecosystem level. The inventory framework was presented at the IAMOT Conference 2018, in Birmingham. The concepts included in this framework are summarised and defined in Appendix B. Chapter 6 will discuss the first of the framework evaluation phases, by investigating the MomConnect health platform .

Chapter 6: Framework evolution Part 2: Preliminary framework evaluation

Chapter 6 key objectives:

- Give a theoretical background on the MomConnect initiative
- Relate the MomConnect initiative to the inventory framework
- Evaluate the relations between the framework and MomConnect
- Present the modifications of the inventory framework

6.1 Introduction

The evaluation of the framework forms Part 3 of the Research Design, shown in Figure 56. The inventory framework was evaluated by means of theoretically investigating a successful South African health platform and linking it back to the inventory framework. The evaluation of the inventory framework through investigating the MomConnect platform formed a part of the research presented at the 2018 South African Biomedical Engineering Conference (SABEC) [202]. The article was also included in IEEE Xplore on 24 May 2018. This preliminary evaluation resulted in the one-dimensional framework comprising three ecosystem canvasses. The next step of the evaluation process was the semi-structured interviews as shown in Figure 57. This chapter presents the preliminary validation of the framework through the MomConnect initiative. The modifications and adaptations to the framework are also discussed.

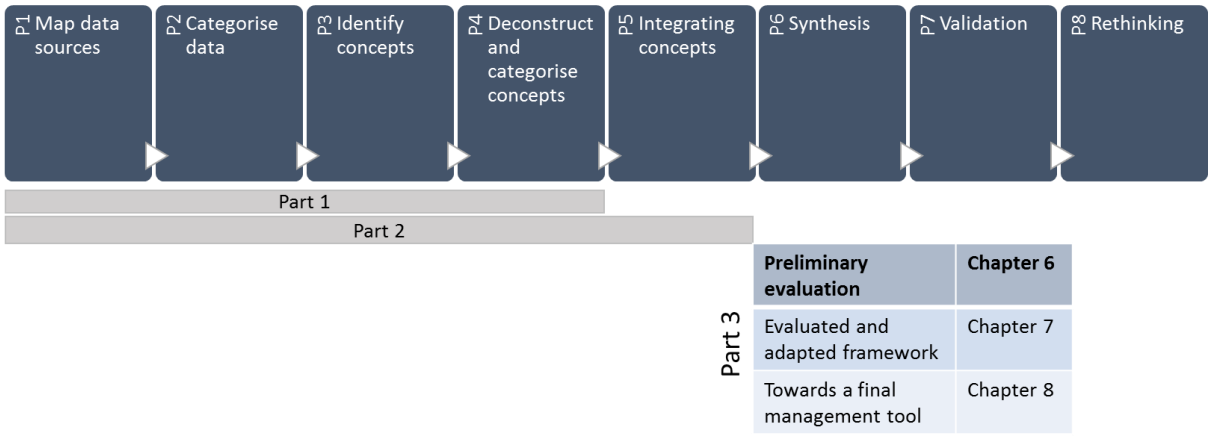


Figure 56: Document context diagram: Chapter 6

6.2 Preliminary validation: The case of MomConnect

The purpose of this section is the initial evaluation of the inventory framework when related to an existing healthcare platform within the South African health context. The preliminary validation was also done to provide insight into the relationships between concepts included in the inventory framework and thereby result in the formulation of more applicable categories. Subsequently, the MomConnect evaluation phase resulted in an improved understanding of technology platforms and the SA health context and the inventory framework could subsequently be modified and adapted.

The investigation was conducted on a National Department of Health (NDoH) initiative - the MomConnect digital health platform. MomConnect was selected based on three main reasons:

- The success and scale of the platform
- The platform operational context (SA health)
- The data availability of the platform initiative

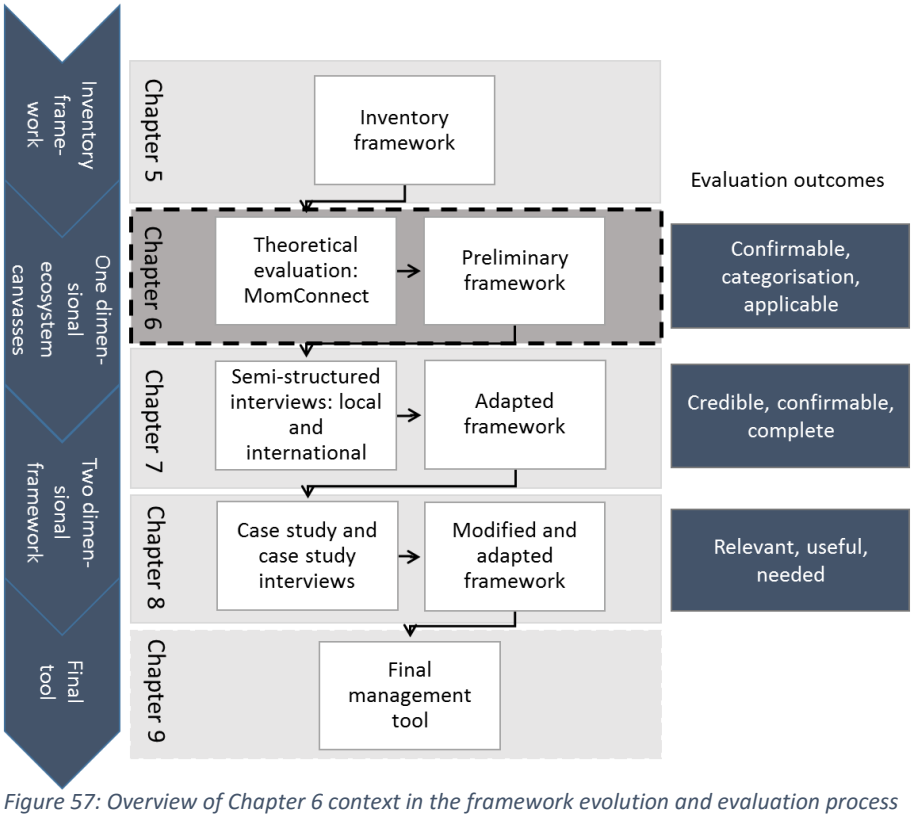


Figure 57: Overview of Chapter 6 context in the framework evolution and evaluation process

The investigation focused on three aspects that could be related to the inventory framework content. These aspects were: (1) strategic management, (2) the platform architecture itself and (3) its user-specific design.

The data collection for the case study comprised an Internet and document search to gather publicly available information about the MomConnect platform. The limitations of this data gathering method are acknowledged. Both the search and subsequent data analysis phases were guided by the inventory framework. In the next section a brief summary of the MomConnect platform is given.

6.2.1 Background on MomConnect Platform

The MomConnect initiative is an exemplary case of a successful, large scale, digital health solution in a low-and-middle income country (LMIC) and how integration with existing health platforms towards a common goal and leveraging of data can be approached [18]. Within its first year of operation, MomConnect had over 500 000 registrations and a network of more than 20 partners [18], [29].

The main goals of the MomConnect platform are "*[to deliver] targeted stage-based health information to pregnant and postpartum women, [to] enable women to reach out with pressing questions, and [to] establish an important feedback loop to improve services*" [18, p. 6]. MomConnect consists of six key components, namely an integrated back end system, a front end system using Unstructured Supplementary Service Data (USSD), a Short Message Service (SMS) helpline, a clinic experience rating system, data collection in the National Pregnancy Registry (NPR), and pregnancy stage-based information delivery. The findings on the strategic management, platform architecture and user-centric design of the MomConnect initiative are discussed next.

6.2.1.1 Strategic leadership and goals

Three crucial questions were asked in an attempt to reduce the high maternal and infant mortality rates in SA which helped formulate the problem definition [18]. These questions included the following:

- How can pregnant women and mothers be educated with regard to their own health as well as the health of their children?
- How can the target market of 1.2 million pregnant women be reached?
- How can the quality of service experienced from healthcare providers be improved?

As a result of clear problem identification and goal congruency between MomConnect partners, a digital platform was developed that provides access to information (educate mothers), improves access (widespread use of mobile phones) and enables feedback (rating of services) [20].

Seebregts et al. [176] maintain that good strategic leadership is arguably the most crucial factor for MomConnect's success. The program is free of charge for pregnant women, was launched by the South African Minister of Health and led by NDoH officials [20]. The clear goal of the initiative ensures leadership focus and direction for all partners [18]. The MomConnect Task Team and stakeholders are kept up to date with regard to the project through the circulation of usage data. This allows evidence-based management decisions [176].

Based on the stated problem definition and resultant questions, the scope of the project and its implementation roadmap were established. This enabled focus on the system life cycle functionality requirements [176]. Emphasis was also placed on understanding the ecosystem in which the system operates and subsequently designing the program and its infrastructure [176]. The team had to identify all actors and their diverse activities involved in the value chain and develop solutions accordingly [176].

The MomConnect platform generates value for multiple actors within its ecosystem: healthcare service providers, end users, the government and donor community [18]. Healthcare service providers are granted access to the service delivery ratings and feedback to improve their service delivery. The end users have access to information, support throughout their pregnancy and the service comes at no cost. This allows the South African government to work positively towards their health system development goals while donors have the opportunity to leverage the technology infrastructure, systems and lessons learnt in order to implement similar programs [18].

6.2.1.2 Technological infrastructure

The technological infrastructure mainly comprises previously existing mHealth and eHealth components [176]. These components were proven to be reliable, trustworthy and effective and were formerly implemented successfully in low-income environments. One of the utilised sources was the Mobile Alliance for Maternal Action South Africa (MAMA SA) initiative [20], [176]. The MomConnect team could therefore leverage the previously implemented components. As a result, the focus could be placed on configuring the infrastructure specifically for the end users and integrating these components with the NDoH standards and the Health Normative Standards Framework (HNSF) [176]. Open source OpenHIM software is used in the interoperability layer [18].

The implementation of the infrastructure proved stable as it evolved without any service interruptions. It has a modular structure enabling continuous improvement and adaptation to comply with evolving NDoH infrastructure [176]. The multiple partners involved in the project enable innovative skills from the private and academic sectors to be leveraged while developing within public health [18].

MomConnect prioritises data privacy and security. The system integrates with the District Health Information System 2 (DHIS2) and with the NPR. A clinic identification system was designed in order to individually access and track clinic specific aspects [20]. Security measures were also undertaken including encrypted data transmission, a secure data centre, firewall protected servers, restricted access and web-based console and alerting system infrastructure [176]. The importance of measuring its performance was noted and a monitoring and evaluation program was therefore implemented [18].

6.2.1.3 End-user design and user-specific design

The MomConnect team prioritised their target market and their context of use. Research done by MAMA SA paired with consulting medical professionals, mothers and local partners provided insight into the content to be displayed [18]. South Africa has a 94% adult literacy rate and texting was found to be the best method of engaging with the target market [18]. Unstructured Supplementary Service Data (USSD) and Short Messaging Service (SMS) do not require smartphones and were therefore chosen as the protocol of use [20], [176]. End-user usability was considered in the back-end development of the platform by optimising the technology for minimal components, simple standards and user friendliness [176].

6.2.2 Applying the preliminary framework to the MomConnect platform

The nature of MomConnect had to be determined prior to the investigation. The nature of the platform has an influence on the importance of several concepts included in the framework. Subsequent to developing a better understanding of the nature of the platform, the inventory framework could be linked to the MomConnect initiative.

6.2.2.1 Defining the MomConnect platform

The inventory framework was developed to be as generalised as possible. Therefore it was important to firstly define the MomConnect platform and identify its scope in order to exclude non-related concepts within the framework. The MomConnect platform's defining aspects include the following:

- Non-commercial, therefore excluded all marketplace related aspects;
- Free of charge to mothers and caretakers;
- Internal platform (no external developers), therefore some platform owner level and developer level concepts merged.

6.2.2.2 Application of framework to MomConnect platform

The inventory framework comprises three different levels: platform owner, developer and end user. The platform owner level includes both the platform and platform owner firm aspects. In the case of MomConnect, which is classified as an internal platform, the platform owner level and developer levels are both applicable to the same group of people – the comprehensive team behind the initiative. In contrast, in external platforms, the software platform is open for external firms to innovate by creating their own products and services using the platform [93]. The inventory of concepts following the application to the MomConnect platform is shown in Figures 58, 59 and 60. These figures include only the concepts that could be applied and linked to the MomConnect platform.

At the platform owner level in Figure 58, MomConnect could be linked to the strategy, architecture, governance structure, internal organisation and operations categories. Approximately all concepts within the first two categories could be related to the MomConnect platform. The increase in omitted concepts from the governance structure and internal organisation categories is mainly due to the limited availability of information with regard to the internal functioning of the initiative. The developer level of the framework also applies to the platform owner and is shown in Figure 59.

Figure 59 should be interpreted from a platform management perspective when viewing the wider ecosystem partners and the creation of products and services using the software platform. Information regarding the entry barriers, ecosystem-related concepts, the architecture, support structures and methods of control of the MomConnect initiative were identified. As the platform involves multiple partners and stakeholders, there were concepts that related to an ecosystem perspective. The initiative also leveraged the innovative skills of public and academic partners and allowed them to share innovations.

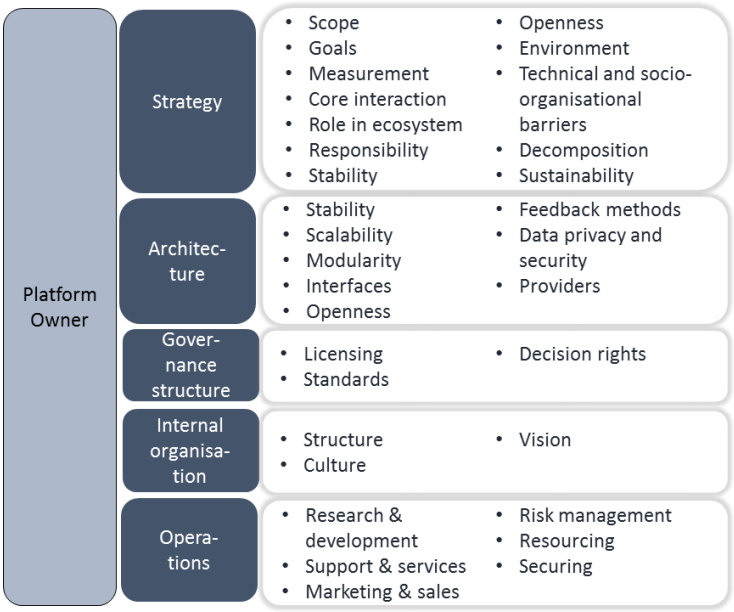


Figure 58: Preliminary evaluation: Applicable platform owner level concepts

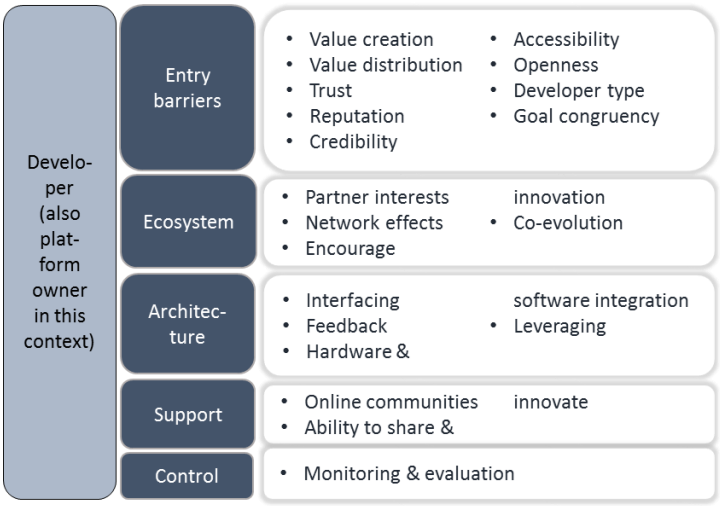


Figure 59: Preliminary evaluation: Applicable developer level concepts

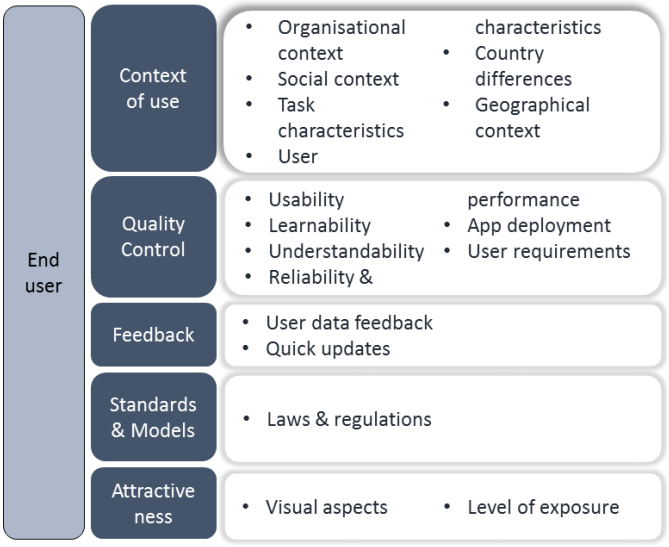


Figure 60: Preliminary evaluation: Applicable end-user level concepts

The third and final level of the inventory framework shown in Figure 60, comprises the concepts that should be considered with respect to the end users. In the case of the MomConnect platform this refers to the mothers, caretakers and the healthcare workers. The categories that could be applied to the MomConnect platform included the context of use, ensuring quality during app use, enabling user feedback, and considering the attractiveness of the app for end users.

6.3 Modification of framework

Subsequent to the application of the framework to the MomConnect health platform, changes were made to the framework. This included additional concepts that were added to the framework and restructuring of certain categories within the framework. The modifications to the inventory framework were as a result of this first evaluation stage (E1) and its context is shown by the highlighted block in Figure 61. Figure 61 indicates the modifications to the framework subsequent to each of the three evaluation stages. The remainder of the elements in the diagram will be presented in Chapters 7 to 9. The iterative nature of the framework can be seen as well as the evolution of the framework.

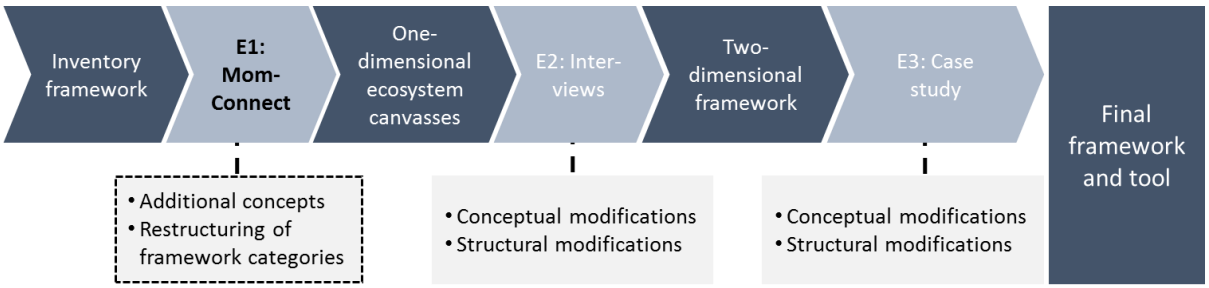


Figure 61: Context of framework modification and evolution: E1

6.3.1 Additional concepts added to framework

The first addition was a monitoring and evaluation (M&E) component at the platform owner level. The concept of sustainability was also added. From the data it is clear that the platform strategy should be designed for sustainability from the beginning. From the MomConnect data, the importance of strategic leadership and clear goals were emphasised, supporting the inventory framework. It is also clear that in order to gain insight into the internal organisation of the initiative to apply the framework to its full extent, further qualitative data will have to be gathered. Therefore the case study in Chapter 8 formed an important part of the evaluation process.

From this preliminary evaluation it became evident that the inventory framework could be successfully applied to a developing country health platform. This provided a starting point for tailoring the inventory framework specifically to the SA health context. The application proved that the inventory framework could provide useful insight into the concepts a platform owner should consider in the design and management of a platform and its ecosystem.

6.3.2 Restructuring of the framework into practical categories

In addition to the added concepts and theoretical insight obtained during the preliminary evaluation of the inventory framework, it also led to the reconstruction of the categorisation within each of the three levels. This was as a result of a better understanding of the concepts and how they would possibly be interpreted by a platform owner. Therefore all three levels of the inventory framework were reconstructed. The platform owner level was adapted by transforming the five overarching categories of the inventory framework into four categories and corresponding subcategories as shown in Figure 62. The resulting main categories were platform design, platform ecosystem design, platform owner design and evolution. These categories were found to be more descriptive and comprehensive.

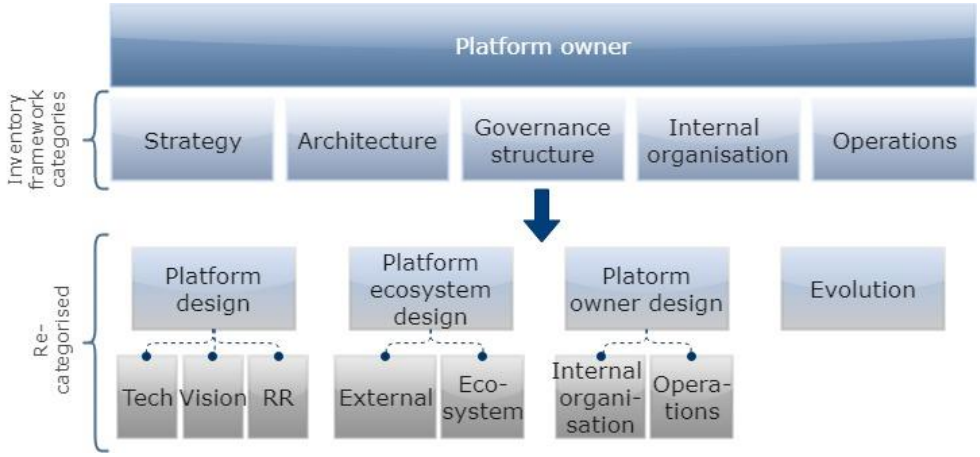


Figure 62: Restructuring of platform owner level categories

The developer level of the framework was transformed from having seven categories into five categories with relevant subcategories as illustrated in Figure 63. The five main categories were entry barriers, ecosystem, technology infrastructure, control and support. The approach of adding subcategories rather than more main categories was found to be more insightful and logical. The standards & models categories for both the developer and end-user levels were disregarded as they did not give any additional insight.

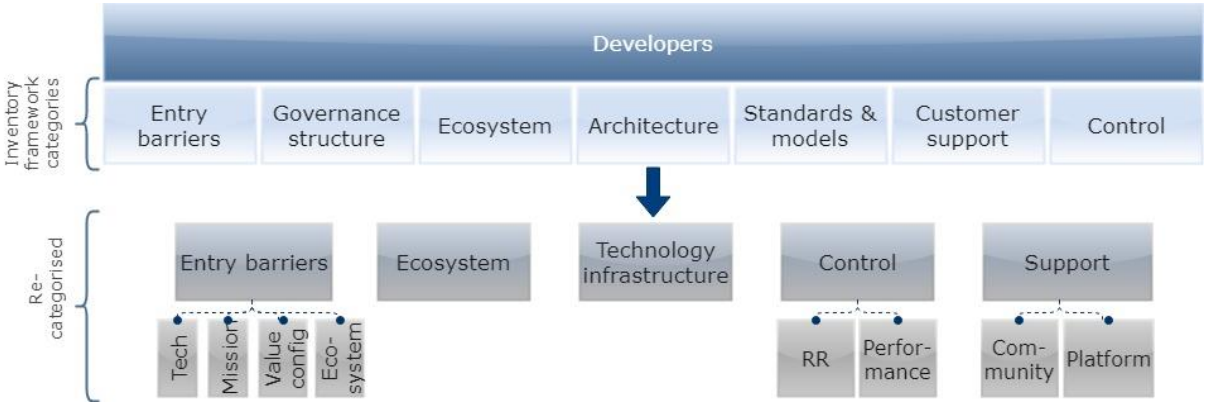


Figure 63: Restructuring of developer level categories

The final level of the inventory framework, the end-user level, experienced the least changes. The five overarching categories were adapted to form three categories with subcategories where applicable. The main categories were context of use, quality control and interface and design. The modification of the framework level categories is illustrated in Figure 64.

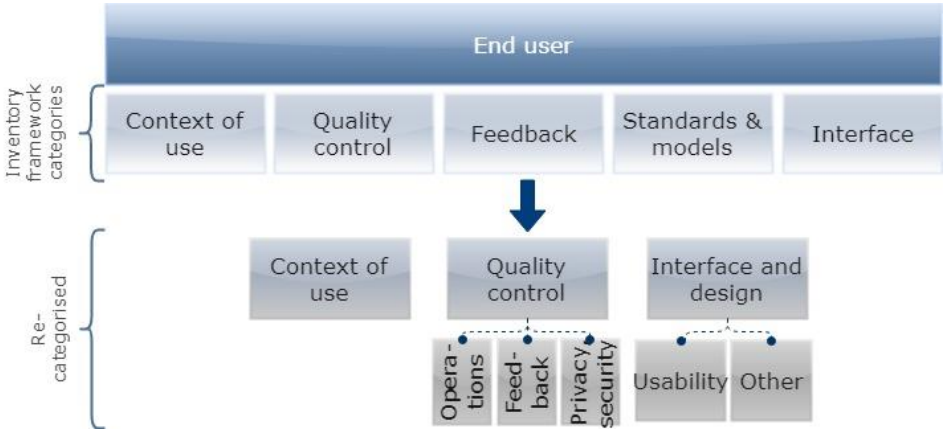


Figure 64: Restructuring of end-user level categories

Subsequent to the recategorisation of the framework categories, each concept within the framework was translated to one or more corresponding questions. Drawing from the FMT investigation and analysis from Section 4.8 as well as the Business Model Canvas [188], questions were added to make the framework more practical. The framework aims to be generalised for use with more than one type of platform. By translating the concepts into questions, the framework is not constraining the platform owner to think of one type of platform. It simply stimulates thoughts and simultaneously clarifies the definitions of the concepts. The three framework levels with the adapted main categories are indicated in Figure 65 on the next page. Each main category could be segmented into subcategories (if applicable) and their corresponding concepts. Each concept had one or more guiding and clarifying questions. This concluded the first part of the framework evaluation process.

6.4 Chapter 6 Summary

The main focus of Chapter 6 was to apply the inventory framework to the MomConnect health initiative. The MomConnect initiative was related to each of the inventory framework levels and subsequently certain modifications and additions were made to the framework. Subsequent to the MomConnect evaluation, further evaluation of the framework included additional interviews and a case study. The following chapter includes the second phase of the evaluation process, namely the semi-structured interviews.

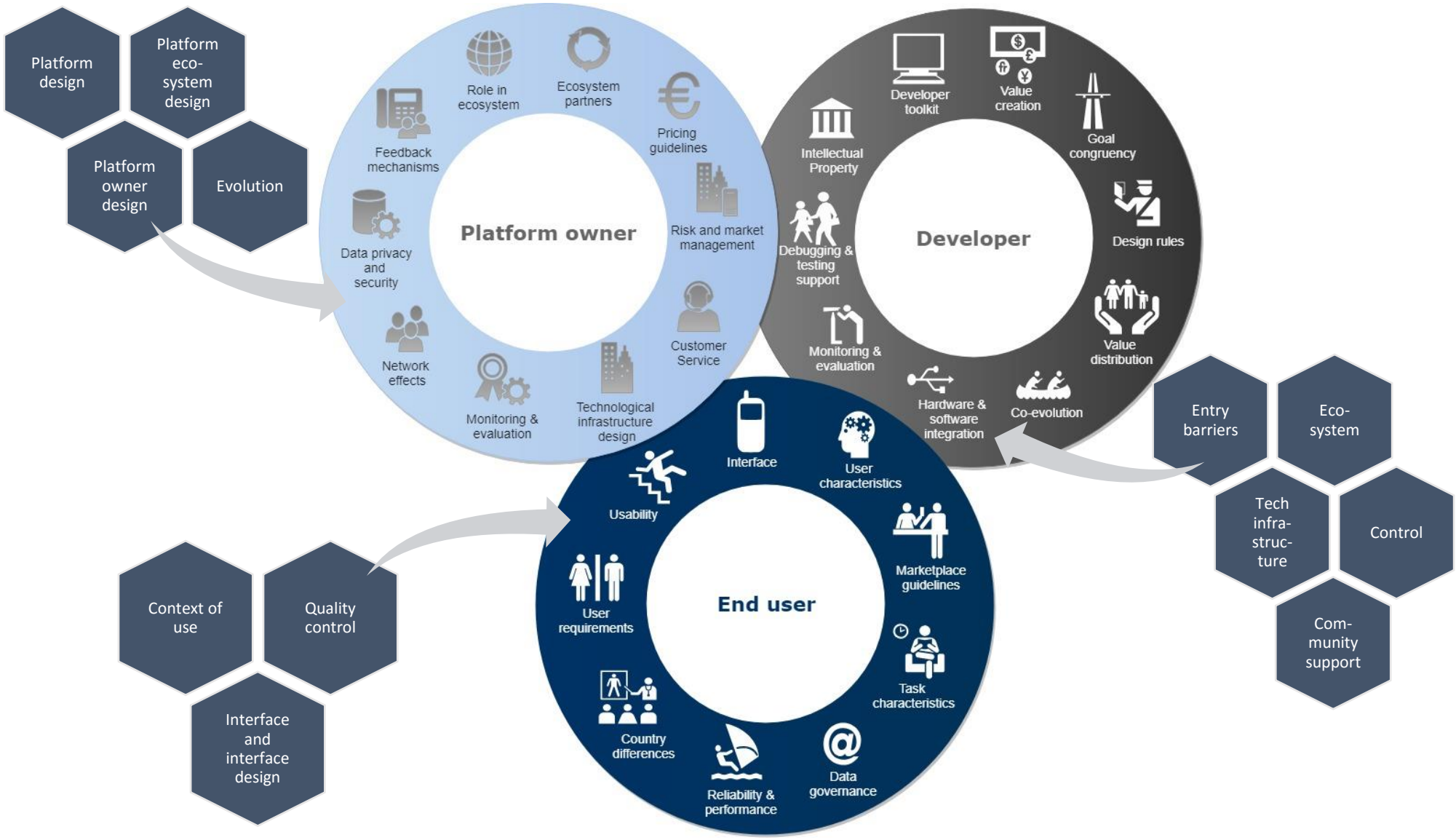


Figure 65: New main categories of the three framework levels

Chapter 7: Framework evolution Part 3: Evaluated and adapted framework

Chapter 7 key objectives:

- Introduce the concept of semi-structured interviews
- Describe the semi-structured interview process followed
- Analyse the semi-structured interview data
- Present and discuss the findings from the data and relate how this affects the framework
- Highlight any modifications done to the framework as a result of the case study data analysis
- Present and discuss the modified and adapted framework

7.1 Introduction

The second part of the evaluation process comprised semi-structured interviews. The outcome of the semi-structured interviews was the evaluated and adapted framework, as shown in Figure 66. The semi-structured interviews were used to confirm the concepts and categories of the framework and to identify any missing concepts. Following the evaluation of the framework through these interviews, the framework was modified and adapted. The layout transformed from a one-dimensional framework comprising the three ecosystem levels to a two-dimensional framework with components specific to South Africa and health added. The framework evolution is shown in Figure 67. The semi-structured interviews formed a key component to gain insight into technology platforms in the South African health context.

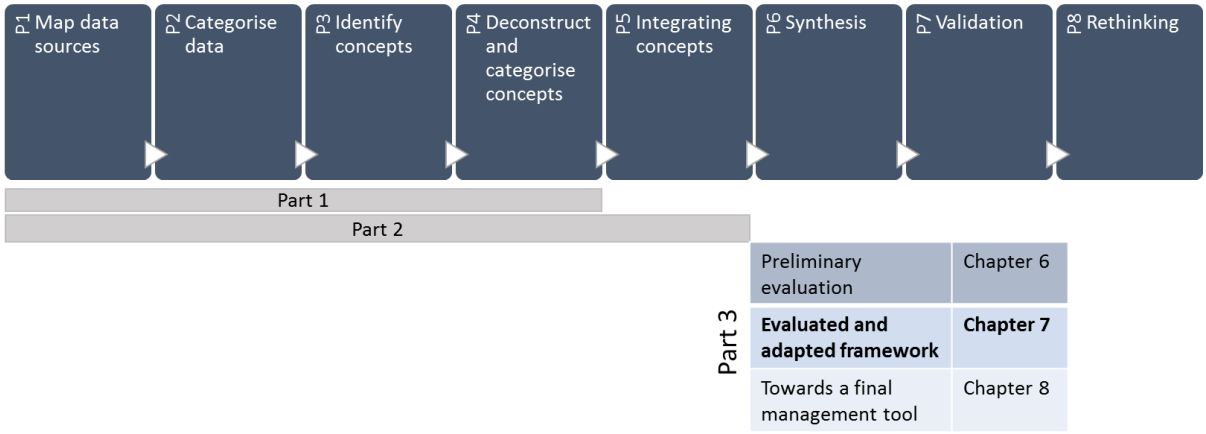


Figure 66: Document context diagram: Chapter 7

This chapter commences with an overview on semi-structured interviews, followed by the process that was followed to conduct these interviews. The data analysis comprised three coding cycles, which led to the results and conclusions, and the framework additions and modifications are also discussed. The evaluated and adapted framework is also included and discussed.

7.2 Semi-structured interviews

The six-stage process developed by Rabionet [68], was used as a guide for the semi-structured interviews. The stages include selecting the interview type and establishing the ethical considerations, followed by formulating the interview protocol. Subsequent to the protocol, the interviews are conducted, the data analysed and the final stage involves reporting the findings. Table 37 shows the

six stages, their descriptions and how they were implemented in this research. The application of the six-stage process will be described next.

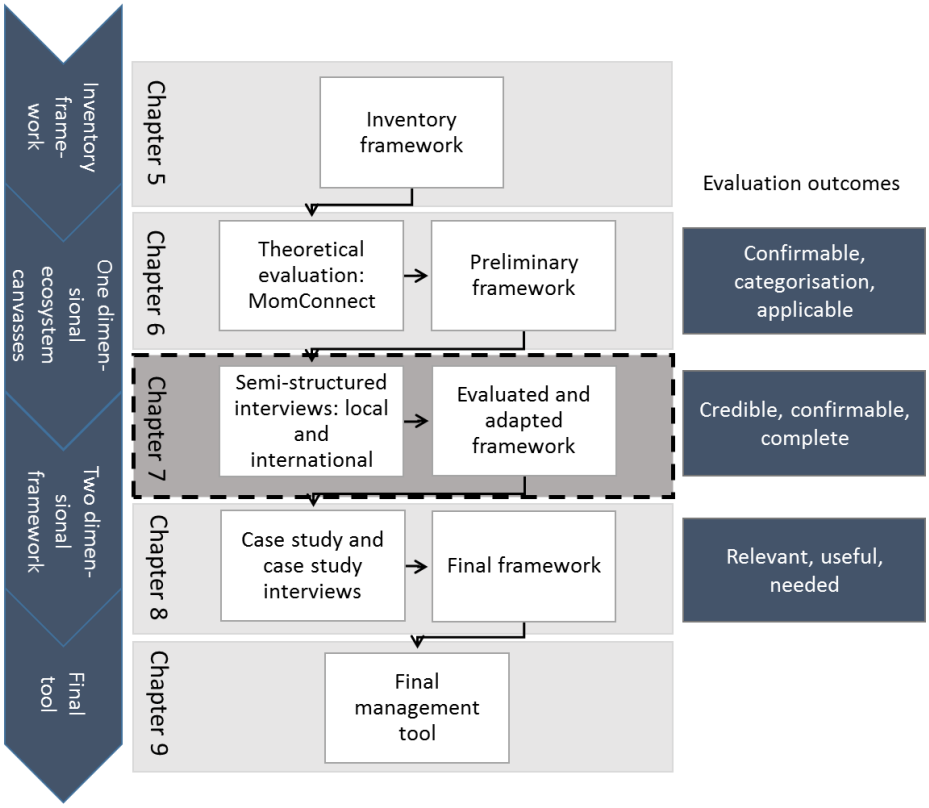


Figure 67: Overview of Chapter 7 context in the framework evolution and evaluation process

Table 37: Six step semi-structured interview process [68] *and implementation details*

Stage	Stage description	Within this research
Select interview type	Choose between structured, semi-structured and unstructured interviews	Semi-structured
Establish ethical guidelines	Investigate possible consequences, consent, confidentiality and protection issues regarding the interview.	Ethical clearance from REC, refer to Section 1.8
Craft interview protocol	Gather information regarding context and develop questions and follow-up probes.	Section 7.2.2
Conduct interviews	Conduct and record the interviews.	Section 7.2.3
Analyse the interviews	Data analysis	Section 7.2.4
Report the findings	Presenting the results of the interview data	Section 7.2.5

7.2.1 Selecting the type of interview

Interviewing is a powerful way to gain understanding regarding a topic and it is particularly useful when personalised data is required and probing is necessary [43]. Semi-structured interviews were chosen as they are more explorative than structured interviews, but still rely on an interview protocol to guide the researcher and thereby result in comparable data across the interviews conducted. Therefore, the interviewer can probe if the opportunity to explore certain themes or investigate other topics arises [67]. This approach suited the researcher's evaluation criteria for the interviews, namely to verify the concepts of the framework, but still be open to new insights and additions.

7.2.2 Interview protocol

Creswell [43] suggests developing an interview protocol which includes the interview information, the standard instructions that should be followed throughout all interviews and the questions to be asked.

Rabionet [68] states that the interview protocol has two main components: (1) interviewer introduction and background, and (2) the interview questions. These components also formed the basis of the interview protocol for this research.

The first component comprised two sections, namely a background presentation and an interviewee consent form. Firstly, a concise overview of the research context and the aim of the framework were presented to the interviewees by means of a MS PowerPoint presentation. The presentation was given either on a computer or printed out and handed to the interviewee. The presentation is included in Appendix D. Secondly, a consent form was given and explained to the interviewee. The consent form explained the purpose of the interview, the REC stipulated ethical considerations and how the data will be used.

During the development of the second component, the interview questions, a problem arose: more than one hundred concepts distributed throughout the three different ecosystem levels of the framework needed to be validated. Asking one hundred questions of an interviewee is not practical. As a solution to this problem, the researcher formulated five platform development parts: (1) platform core, (2) ecosystem and environment, (3) platform design and governance, (4) managing and operation and (5) evolution. These five parts, shown in Figure 68, were specifically formulated to relate to the full spectrum of concepts within the framework. This meant that each of the one hundred concepts in the framework could be linked to one or more of these overarching parts. The interview could therefore comprise a discussion of these five parts and the researcher could probe the interviewees where needed to discuss the desired concepts. However, the interviewees were not bound to discussing specific concepts and subsequently, voids or new insights into the framework could be obtained.

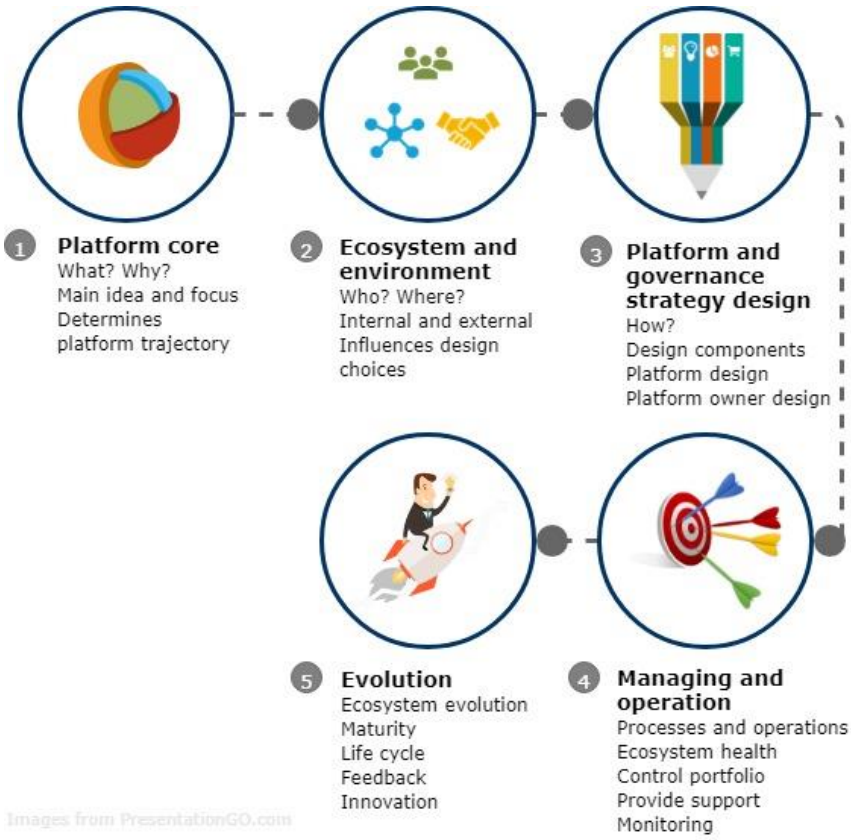


Figure 68: Five overarching parts identified to aid in interview simplification

The platform core refers to the 'what' and 'why' questions relating to the platform, forming the foundation of the platform design, development and implementation. The second category refers to the ecosystem and environment and aims to answer the 'who' and 'where' questions regarding the

platform and ecosystem. This category not only considers the platform ecosystem, but also the external environment of the ecosystem and its effect on the platform and platform ecosystem. The third category is platform design and governance design which aims to answer the 'how' questions regarding the design of a platform and ecosystem. This section considers how the platform will practically be realised. The fourth category refers to platform managing and operation and included concepts that can be used to guide the platform owner on how the platform and ecosystem could be managed and operated. The fifth and final category is platform evolution which focuses on how the platform should evolve and what aspects of the platform or platform ecosystem should evolve.

Each of the concepts within the three framework levels were linked to one or more of the platform development categories. Figure 69 shows an excerpt from MS Excel to illustrate the process followed by the researcher to link each concept of the framework to one or more of the five overarching categories. Subsequently, the researcher could probe interviewees to discuss relevant concepts when applicable. The illustration in Figure 69 focuses on some of the platform owner level concepts. The platform owner level has a subcategory called platform design, which has further subcategories namely technology infrastructure and vision. Each of these second-order subcategories has concepts dedicated to it as shown in the fourth column in Figure 69. Each of these concepts was then related to one or more of the overarching platform development parts as indicated by the '1's' in Figure 69.

Framework concepts				Applicable				
Category 1	Subcategory 1	Subcategory 2	Subcategory 4	Part 1 Platform core	Part 2 Ecosystem and environment	Part 3 Platform design and governance	Part 4 Manage ecosystem and health	Part 5 Evolve
Platform owner	Platform design	Technology infrastructure	Stability			1		
			Scalability			1		
			Interoperability			1		
			Toolkit			1		
			Openness			1		
			Feedback methods			1	1	1
			Security			1		
			Key activities			1		
			Providers		1	1		
		Vision	Scope	1				
			Goals	1				
			Measurement			1	1	

Figure 69: Illustration of how the concepts were categorised into the overarching parts in MS Excel

As a result of linking all the concepts to one of the five platform development parts, the roadmap for the interview comprised only these five platform development categories, instead of one hundred different questions. The aim was to delve into each of these five parts and subsequently ask questions that would probe the interviewees to touch on the framework concepts. Either four or five questions were formulated for each of the five parts, resulting in 21 standard questions from which probing could follow. The researcher developed these questions carefully to enable each of the framework concepts to possibly be discussed during the interview. The interview roadmap and the 21 related questions can be seen in Appendix B.

Throughout the formulation of the five overarching parts, the researcher noticed a void specifically in the ecosystem segment of the framework. This void was concerning the external environment of the ecosystem. As a result, six concepts were added to the framework regarding its external environment: (1) key trends, (2) market and (3) industry forces, (4) external competition, (5) value chain requirements and (6) macroeconomic forces. Following the successful development of the interview protocol, the interviews could be conducted.

7.2.3 Conducting the interviews

In an attempt to standardise the interviews, the researcher developed a six-step process that could be repeated for each interview as shown in Figure 70. The first step was to obtain the required consent from the interviewee, followed by the presentation on the project background and general

information. Thirdly, the interview outline was given and described to the interviewee. In order to collect the data during the interview, the fourth step was to voice-record the interview. Subsequently, the interview questions were asked while adhering to the interview outline. This formed the fifth step of the interview process and was complemented with probing the interviewees as required. The sixth step entailed the interviewee asking any questions or highlighting any concerns regarding the framework. The final step was to transcribe the interviews into MS Excel where they could be analysed and coded. The approach to the data analysis is discussed in the next section.

Figure 70: Six-step interview process followed

A total of nine interviewees were considered for this part of the evaluation process. The interviewees were selected to represent diverse viewpoints, experiences and groups of people that relate to technology platforms in the South African health context. These nine interviewees can be grouped based on five different aspects as shown in Table 37. Due to the multidisciplinary nature of the research, certain interviewees were selected as experts in the fields of innovation, healthcare, ecosystem management and governance. Five of the interviews were also conducted in the United Kingdom (UK) and yielded insights into platform differences between developed and developing countries. Three of the interviewees focused on software development and could therefore provide insight into the mind of a developer. The other interviewees could be approached as platform owners. The interviewees comprised a mixture of industry experts on innovation platforms, transactional platforms or both. The final group that the interviewees could be classified as, is being an expert in health. Each interviewee could relate to one or more of the groups in Table 38.

Table 38: Interviewee grouping options and motivations

Interview grouping options	Reasoning
Expert or industry interviews	Multidisciplinary nature of research, therefore verify framework concepts from different viewpoints
Local or international interviewee	Comparison of South Africa with international industry
Platform owner or developer perspective	Approaching the framework concepts from both sides of the boundary resources
Type of platform	Gain insight from both innovation and transaction platforms
Related to Health	Gain insight into health platforms

7.2.4 Interview data analysis

Following the completion of the interviews, the data had to be analysed. Creswell [43], suggests a six-step process for qualitative data analysis shown in Figure 71. This process was followed as it provides a comprehensive approach to analyse and present the data in a structured manner. The last three phases are all condensed into Sections 7.2.5 and 7.2.6.

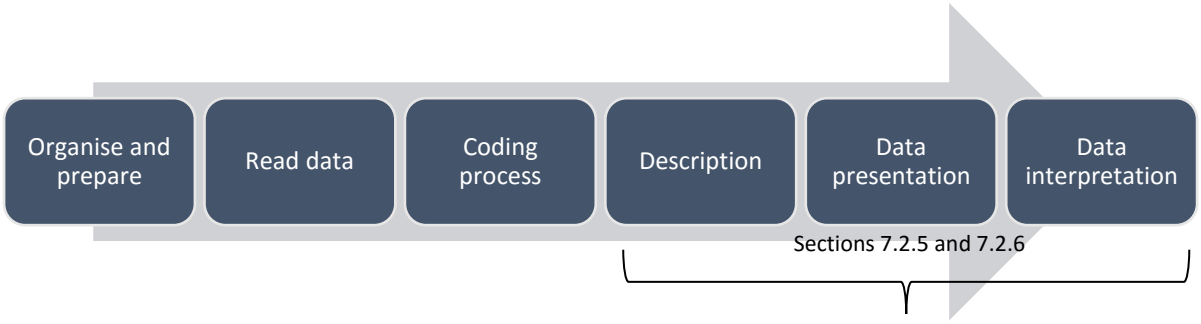


Figure 71: Data analysis process in qualitative research [43]

The interview questions were already categorised into the five platform development parts which simplified the structuring of the transcribed data. As a result, the data from each interview could be divided into these five parts. This allowed for a logical and structured layout in MS Excel that was consistent for each interview, thereby facilitating the data analysis process. Whilst structuring the data, the interviews, the researcher used the structuring of data as the first reading prior to the subsequent analysis.

Following the structuring and first reading of the data, the coding process commenced. Coding is a key link between collecting data and explaining its meaning. Qualitative data coding is formulated by the interpretation of a researcher with the aim to assist in pattern detection, categorisation and other relevant analytic processes [77]. A code is a word or short phrase assigned to capture or summarise an attribute for a portion of data [77]. The data can include interview transcripts, literature, field observation, journals or other documents. Patterns of coding include: similarity, difference, frequency, sequence, correspondence and causation. Researchers should also be aware of the two lenses that affect the coding process: (1) the researcher's analytic lens, and (2) the filter covering that lens. The filter has an effect on how the data is perceived and interpreted by the researcher [77].

The coding process applied to the interview data differed from that used in the systematic literature review in Chapter 3. This can be attributed to the aim of the systematic review which was to get an overview of the concepts and relevant literature. The aims of the interview data analysis were to verify concepts and to further delve into themes, patterns and categorisation of the data where applicable. Therefore, more explicit coding was required. MS Excel was chosen as the coding tool, as the researcher is familiar with its functionality and also used it for the systematic literature review. The use of other technological tools such as Atlas.ti was therefore not pursued. The number of interviews and the subsequent data were not demanding a more intense tool. Basit [203] compared manual to electronic coding and concluded that it depends on the size of the project and the expertise of the researcher. Saldana [77] recommends using manual coding for first-time or small-scale studies. Therefore, the nine interviews for this study were manually coded with the help of MS Excel.

Coding occurs in cycles where each cycle leads to further refinement [77]. Typically first- and second-cycle coding is applied to such data. For this project, three coding cycles were found sufficient to analyse the data obtained during the interviews, as described in Figure 72. The first cycle focused on establishing whether the interviews validated the concepts and categories within the framework. The second cycle adopted five provisional lenses based on notes and highlights from the first cycle and investigated any additional concepts that should be added to the framework. The final cycle yielded themes, patterns and deeper insights into the data. The results and conclusions of each cycle will be discussed next.

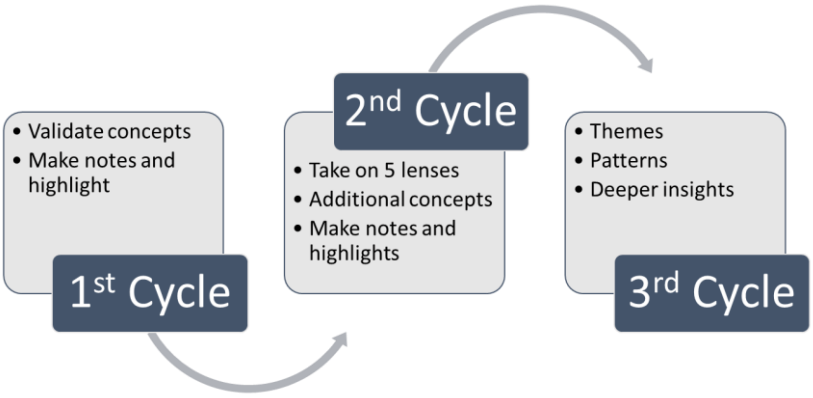


Figure 72: Three coding cycles conducted during interview data analysis

7.2.5 Results and conclusions

This section discusses the three coding cycles and the corresponding data analysis and results. This includes the validation of the framework concepts and categories, highlighting areas of disagreement or voids, identification and discussion of themes and patterns and additions to and modifications of the framework. The five platform development parts formulated for the interviews allowed for comparison between the interviews and also to easily integrate new concepts and ideas. It also facilitated the identification of patterns and themes.

7.2.5.1 First cycle coding

The purpose of the first cycle coding was to determine whether the existing concepts included in each of the three levels of the framework (platform owner, developer and end user) were applicable and valid in the platform and platform ecosystem context. As discussed earlier, there were more than 100 concepts to cover during the interview and the interview outline was therefore divided into five distinct parts. The first cycle coding was conducted on paper and in MS Excel. The approach was to go through each interview's data and to mark which of the concepts were validated. This was done for all the interviews independently. Notes for future cycles were also made by hand.

The interview data in MS Excel was formulated in such a way as to enable the recording of the amount of times each concept in the framework was mentioned or discussed by interviewees. These recordings were added together for each concept across all interviews and then tabulated. The occurrences of each concept within each of the three framework levels are shown in Figures 73, 74 and 75. By tabulating the concepts and sorting them in descending order, trends in popular concepts could be identified and interpreted.

For the platform owner level it could be seen that there was a diversity in concept mentions or discussions throughout the interviews. The two concepts on the platform owner-level that were the most popular amongst the interviewees were platform security and sustainability. Platform sustainability referred to both technology sustainability and business sustainability. A possible reason for the popularity is the significance of these concepts. Having adequate security mechanisms and protocols, designing and planning for sustainability of the platform and ecosystem and following industry standards are mandatory in a technology platform context.

The distribution of concepts in Figure 73 aligns with the points of parity and points of differentiation that were highlighted during the interviews. Points of parity are concepts that would be considered as the norm for platforms. Without these concepts being implemented in the platform, the chances of success are limited. Points of differentiation refer to those concepts that make the platform stand out from its competitors. The distribution of concepts can also be seen as an informal ranking of concept significance, which provides insight and understanding into the further development and evolution of the framework.

Another factor that influenced the distribution was the nature of the interviewee. The interviewees were a diverse group of experts, platform owners and developers. Therefore not all concepts were relevant to each of the interviewees. Concepts such as conflict management, technical and socio-organisational barriers and investments are not applicable to all platforms and these concepts might not be regarded as important by industry experts, for example.

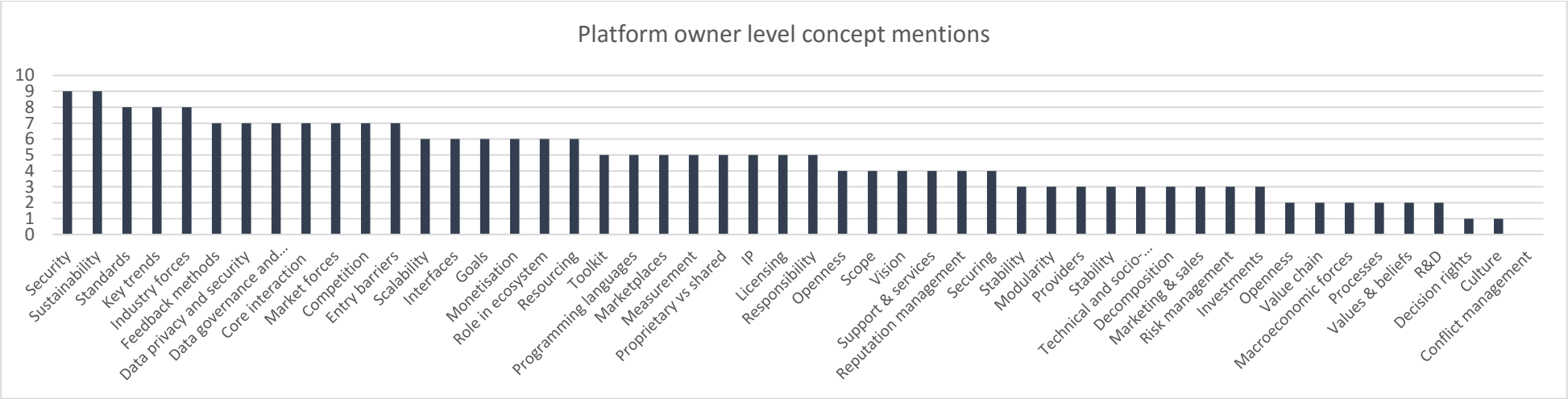


Figure 73: Platform owner level concept mention ranking

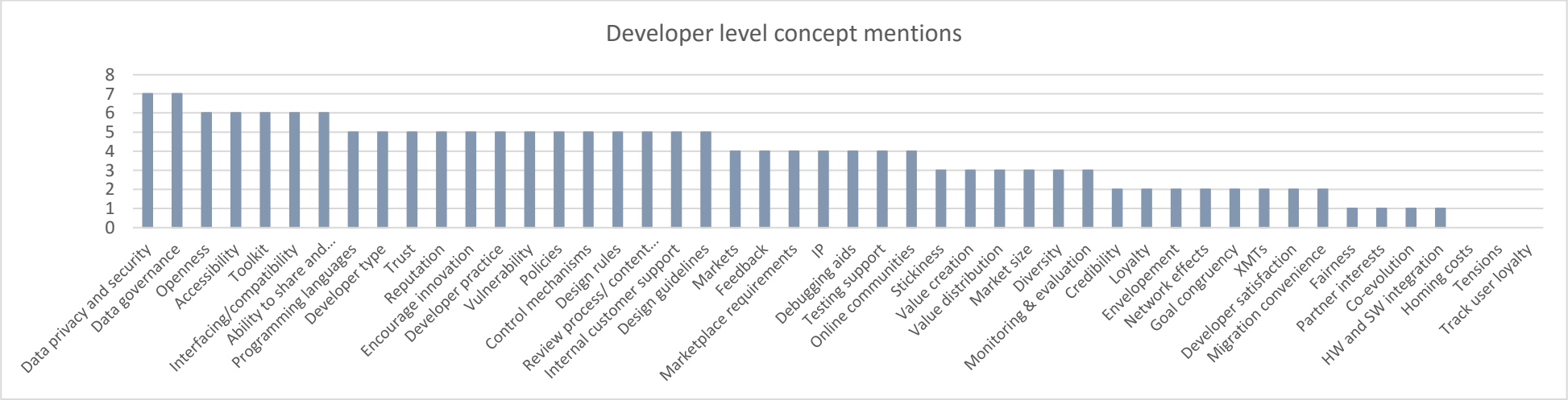


Figure 74: Developer level concept mention ranking

The developer level concept mentions shown in Figure 74 follow a similar distribution. However, there were no concepts that all interviewees mentioned or discussed for this level of the framework. Similar to the platform owner level concepts, data privacy, security and governance are crucial for platform functioning and can be classified as points of parity. As expected, the concepts relating to the enabling of the developers to innovate on the platform, were also popular. These concepts included platform openness, toolkits provided, the ability to share and innovate and accessibility of the platform and its functionalities.

The final group of concepts were those relating to the end users of the products, services and technologies developed using the platform. The concept mentions are shown in Figure 75. The trend from the platform owner- and developer levels continued as laws and regulations, data privacy and security and data governance were the most often occurring concepts. Specifically relating to the framework and its focus area of South Africa and health, aspects such as country differences and geographical context also had a big impact.

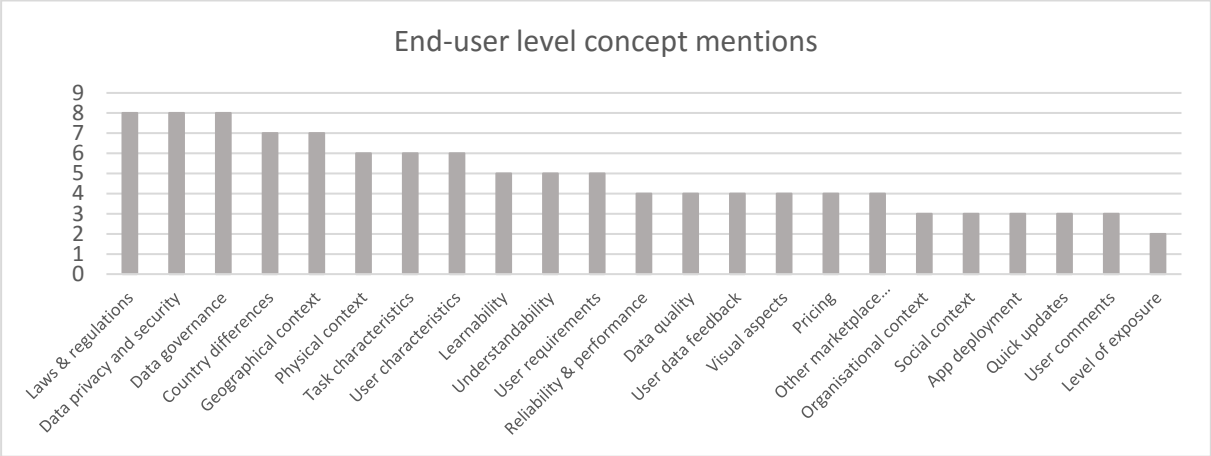


Figure 75: End-user level concept mention ranking

The concept validation was therefore successful, as most of the concepts were mentioned in the interviews. There were however concepts that were not validated, as well as concepts that were not sufficiently validated (meaning it was not validated by more than one interviewee). For the platform owner level, the internal conflict management process did not feature in one of the interviews. Internal conflict management processes refers to the case where the platform is an external platform and developers build applications both from the inside of the platform firm, as well as part of external firms. This could result in internal tensions and conflict as the platform firm needs to provide support to both their own developers and external developers.

On the developer level, three concepts were not validated. The first concept is platform homing costs which is considered an entry barrier. The second concept relates to the performance control that a platform owner can enforce through the tracking of user loyalty. This specifically refers to monitoring why and when developers are leaving the platform and can be implemented as a feedback mechanism. Tension within the ecosystem was also not validated. All these concepts are rather specific and may have been overlooked due to the nature of the semi-structured interview. All concepts on the end-user level were validated.

It should however be noted that all concepts do not carry the same weight or have the same impact. Future work could include investigating the concept importance rankings. It was also clear that most concepts differ in importance based on the platform's characteristics and therefore the platform profile should be determined before using the framework.

7.2.5.2 Second cycle coding

The second cycle of coding adopted five lenses derived from the notes and highlights of the first coding cycle. The aim of this cycle is for further refinement and investigation of any additional concepts that should be added to the framework. Five lenses were adopted for the second cycle coding: (1) health-related, (2) sub-Saharan African (SSA) considerations, (3) platform control, (4) support structures and (5) financing and pricing related aspects. These five lenses, shown in Table 39, were derived from the notes and highlights from the first cycle coding and were chosen as they were emphasised throughout the reading of the data. The purpose of these lenses was to view the interview data through each of these lenses and to gather information regarding each lens respectively.

Table 39: Five lenses adopted in coding cycle

Adopted lens	Description and motivation
Health	Health platforms have different requirements and considerations compared to other platforms. Specifically regarding data, security, privacy and cost of failure.
SSA	Developing countries such as those in sub-Saharan Africa provide a completely different context for technology platforms from those of developed countries such as the UK.
Control	Control forms a major part of the platform owner's responsibility and is key to platform and ecosystem success.
Support	Support forms a fundamental part of drawing developers and enabling them to innovate using the platform.
Financing and pricing	The platform cannot be successfully designed, developed and implemented without sustainable funding. The pricing model of the platform also plays a significant role as an entry and exit barrier, as well as platform sustainability.

The second cycle of coding also pursued the identification of voids in the framework, highlighting of disagreements and the identification of additional concepts to add to the framework. The five platform development parts and the five lenses formed the basis of identifying the voids and additional concepts to include in the framework. These aspects are included in Tables 40 to 42, where each table includes data from a specific group of interviewees. Table 40 combines the interview data from the interviews related specifically to platform owners. Table 41 presents the information from interviews from a platform owner's perspective which also incorporated health and South Africa. The third table, Table 42, included the data from the interviews with a focus on developers using the platform. These tables will be discussed by considering each of the five platform development in terms of the following: (1) confirmed topics, (2) voids and disagreements, (3) additional concepts and then (4) relating to the five lenses, if applicable.

The elements included in Tables 39 to 41 are labelled for traceability and referencing purposes where V indicates an area of verification, D indicates a disagreement or void and AD indicates an additional insight to consider. Take note that the data in Tables 40 to 42 are presented in a concise manner and are therefore not complete, full sentences.

As mentioned previously, the interviews were structured according to five overarching parts. These parts made it easier to compare the data across all interviews and to find themes and patterns. The discussions on the data for each of these parts commences after Tables 40 to 42.

Table 40: Platform owner-focused data results – themes, voids and insights

Interview set 1 (1 and 2 – PO)	Platform core	Ecosystem and environment	Platform design and governance design	Managing and operation	Evolution
Validated themes (V)	V1. Know where you are going and how you can add value	V2. Establish competition V3. Identify key roles in ecosystem	V4. Modular platforms enable developers to focus on design, not technicalities, facilitating innovation V5. Platform consists of several components: UI, databases, push notifications, offline usage, user authentication etc. V6. Design for the level of control that you prefer – determine how much flexibility developers have	V7. Internal platform has more control V8. Scalability of digital	V9. Continuous learning curve
Disagree/ void (D)	D1. Platform and industry life cycle awareness	D2. Health ecosystems have two components: digital and physical components (IoT, data, clinics, doctors) D3. Resistance of adoption in healthcare (HC) platforms D4. Methods of attracting ecosystem participants	D5. All technical design components not on the same level – points of parity vs points of differentiation. Stand out vs ticket to the game D6. Importance of developer documentation D7. Prior to tool: establish type of application can develop D8. Platform accommodate and secure different types of data (specifically HC)	D9. Network effects dependent on size D10. Support will differ between internal and external platforms D11. Automated testing to check platform health D12. Monitoring of apps in an internal platform	D13. Internal platform: App life cycle should be considered in terms of support, security and risk management
Additional insights (AD)	AD1. Value proposition AD2. Have a roadmap of where you want to be AD3. Minimum meaningful viable product – scope very important	AD4. Develop personas and link personas to value and design	AD5. Have different teams in the platform firm – platform design team, solutions team. In other words also modular firm AD6. Security dependent on OS and versions on which the software will run AD7. Pricing strategy: quote based on scope of project, per user pricing, per feature pricing AD8. Data storage: Cloud back ends international AD9. Platform protection tools as a part of risk management. Developers can build bad apps and compromise platform AD10. Pricing differentiation for external and internal platforms	AD11. Support in three dimensions: (1) internal platform support, (2) developer support, (3) end-user support AD12. Security in two dimensions: (1) platform secure from developers and (2) data security	AD13. Evolution in terms of distribution channels – depending on market trends AD14. Securing: new vulnerabilities with each new functionality

Table 41: Platform owner and HC focused data results – themes, voids and insights

Interview set 2 (3,7, 8, 9 – PO and HC)	Platform core	Ecosystem and environment	Platform design and governance design	Managing and operation	Evolution
Validated themes (V)	V10. Establish an initial aim and take it from there V11. Have a main goal and work from there	V12. Identify key players to reach your goal V13. Gain trust in users, specifically with regards to HC V14. External environment key to innovation and forming strategy V15. Private vs public health very different needs and design approaches	V16. Have end-user design mind-set from the start. Know what you are designing for. V17. Developer community is important. V18. Technology in developing countries much different from developed.	V19. Control and monitoring V20. Sustainability plan V21. Scaling plan	V22. Feedback forms a crucial part of the evolution
Disagree/void (D)	D14. Brand	D15. Health will typically have to include public sector components, governments, NHI aspects in ecosystem. D16. Compliance in HC	D17. Platform security will have two components: internal and external to platform firm. D18. Design for offline usage D19. Design for device and for OS and version D20. Diversity of data, especially in HC D21. Different 'components' within a firm D22. Two other things affect platform operation, scaling ability, evolution, R&D, etc.: (1) The size of the platform and (2) the maturity of the platform D23. SOA – build components as black boxes	D24. Sustainability in terms of (1) business and (2) technology D25. Network effects not as prevalent in HC always – not something to always be proud of and tell someone	D26. Competition is not always the best benchmarks, look at other industries as well to evolve
Additional insights (AD)	AD15. Barriers to adoption	AD16. Differences in HC regulations calls for clear initial scope. For example use thermometer for fever, using thermometer for ovulation – all different regulations. AD17. Create profiles and roles of all ecosystem partners	AD18. Pricing: tokens or credits based on performance AD19. In HC: specialised teams for (1) regulatory understanding (2) security understanding AD20. Connectivity is a major aspect to design around (for use in SA) AD21. Interoperability AD22. Data types AD23. User-centric design AD24. Capture data for use AD25. Pricing: External funding such as NDOH, Vodacom AD26. Funding for sustainability	AD27. Encryption AD28. Identity AD29. Cost of data AD30. Connectivity AD31. Devices available	

Table 42: Developer-focused data results - themes, voids and insights

Interview set 3 (4,5, 6 – developer)	Platform core	Ecosystem and environment	Platform design and governance design	Managing and operation	Evolution
Validated themes (V)		V23. Entry barriers are massive for developers. V24. Entry barriers include support, pricing, communities, Languages and FWs and web-based, ease of use	V25. Health platforms will have to consider health from backend to front end V26. The importance of designing for context of use, specifically in HC		V27. Feedback key in developing platform
Disagree/void (D)		D27. Entry barrier: Make sure to use well-known industry standards, not own proprietary	D28. Developer lock in – regarded as an entry barrier D29. Allow for online and offline usage D30. Github account and documentation for developers D31. Think of usability in two dimensions: (1) developers and (2) end users D32. Pricing options: licensing	D33. The ecosystem that uses the platform is an entry barrier. The teams already using the platform affects who joins D34. Internal and external developer support: (1) internal for support and communication and (2) support from community	D35. Follow the trends of large, influential firms in the industry, not necessarily the competitors D36. Look at trends specifically in programming (frameworks, languages that are better for certain uses) D37. Also look at maturity of technologies for evolving (e.g. chatbots)
Additional insights (AD)		AD32. AWS, MS Assure good for back-end services			

The insights relating to each of the five development parts and Tables 40 to 42 are discussed next. This discussion includes agreements, voids and disagreements towards the framework for each of the five parts respectively. The additional insights (from Tables 40 to 42) that were added to the framework will be discussed at the end of this section. There are also several insightful and impactful quotes from the interviewees anonymously included and indicated by italic text.

Part 1: Platform core

The platform core section included the concepts related to the main purpose and vision of the platform. The interviews confirmed the importance of knowing where the platform is heading and to be aware of how this can add value to the ecosystem. It was also clear that in order to build a successful platform an initial aim and scope should be established to direct the platform strategy. The summarised validations, disagreements, voids and additional insights are shown in Table 43 for easy reference during the discussion. Table 43 is populated from Tables 40, 42 and 42.

Table 43: Summary of validations, disagreements and voids: Platform core section

Component	Platform core
Validated themes	Know where you are going and how you can add value Establish an initial aim and goal and take it from there
Disagree/void	Platform and industry life cycle awareness Brand importance

"*As an innovator you have to think of is what you are doing adding value*" – Interviewee E

There were, however, certain voids related to this section that were highlighted throughout the interview data. Two particular gaps were identified: (1) the analysis of the platform life cycle as well as the industry life cycle in which the platform operates and (2) the brand of the platform and platform firm. The stage of maturity in the platform life cycle has a direct effect on the management strategy of the platform and will emphasise different management components such as research and development, competition, innovation and marketing. Secondly, the brand of a platform would specifically play a role in the health industry. An unfamiliar brand would possibly be a barrier for users to enter into the ecosystem, as well as a barrier to adoption. Health is a high-risk industry and therefore users would rather use a trusted firm that has a proven track record.

Regarding open platforms: "*You can get very large economies of scale, but the market must be ready for it. And the platform has to be ready for it. We were not ready for it last time, we were not mature enough for it."*– Interviewee A

"*Platforms that work well only solve one or two major problems.*"- Interviewee F

Part 2: Ecosystem and environment

The concepts relating to the platform ecosystem as well as external influences were categorised within this part. Similar to the previous section, the summarised validations, disagreements, voids and additional insights are tabulated in Table 44 for easy reference during the discussion. Table 44 is populated from Tables 40, 41 and 42.

Table 44: Summary of validations, disagreements and voids: Ecosystem and environment section

Component	Ecosystem and environment
Validated themes	Establish competition Identify key roles in ecosystem Identify key players to reach your goal Gain trust in users, specifically with regards to healthcare External environment key to innovation and forming strategy Private vs public health very different needs and design approaches

	Entry barriers are significant for developers and includes support, pricing, communities, languages, frameworks, web-based, ease of use, etc.
Disagree/ void	Health ecosystems have two components: digital and physical components (IoT, data and clinics, doctors for example) Resistance of adoption in HC platforms Methods of attracting ecosystem participants Health will typically have to include public sector components, governments in ecosystem Compliance in healthcare Entry barrier: Make sure to use well-known industry standards, not own proprietary

In line with the framework, the interview data confirmed the importance of establishing the competitive landscape of the platform and ecosystem. Platform owners should also focus on identifying the entry barriers that developers would face and either design around them or accept the effect that it will have on potential developers who consider joining the ecosystem. The data also verified the importance of identifying the key roles within the desired ecosystem and actively designing for and pursuing these participants to join the ecosystem. Within this ecosystem, trust is required, especially in the health landscape. The diverse needs and subsequent design approaches of the public and private health sectors in South Africa were also highlighted.

"*Look at the ecosystem: what does each of the parties bring to the table?*" – Interviewee F

"*There is this concept I use called pilotitus. You can pilot something your whole life and make good money, but you never get something out there. It is ridiculous the amount of pilots out there. You need to build an ecosystem*."- Interviewee C regarding health platforms in SA

"*There is a huge gap between public and private health. Even in the way that technology works and why it is implemented. If you have a platform for a typical medical aid, it is designed in the background for you to go and see a doctor, because that is how they make money. In public health, it is designed to keep you away from a doctor, because we do not have enough [doctors]. The whole architecture changes*."- Interviewee C

Similar to the platform core part, there were voids identified in the framework. Firstly, health ecosystems in particular can be segmented into their digital and physical components, referring to IoT sensors and data and doctors and clinics respectively. Secondly, resistance to adoption specifically in health should also be noted. Another new insight was as a result of the nature of the public healthcare system where the ecosystem would typically have to consider other stakeholders, in particular the government and financial donors. The fourth void related to a developer perspective and included the accessibility of the platform and also aligning the platform standards with industry-wide standards. Finally, accessibility is a vital consideration prior to platform development. If developers cannot access the platform, innovation would not be possible on the platform.

"*How do we pick which platforms? Tend to come down to the ecosystem using it, the size of the development team using it."*- Interviewee H

Part 3: Platform and governance design

The platform and governance design section of the interviews accounted for the largest portion of data as this is a key focus of this research. Table 45 includes the summarised interview data from Tables 40, 41 and 42 for easy reference during the subsequent discussion. The data includes validated themes, disagreements and voids. The additional insights obtained for this part will be discussed at the end of this section.

Table 45: Summary of validations, disagreements and voids: Platform and governance design section

Component	Platform and governance design
Validated themes	Modular platforms enable developers to focus on design, not technicalities, facilitating innovation Platform consists of several components: UI, databases, push notifications, offline usage, user authentication etc. Design for the level of control that you prefer Developer community Technology use in developing countries is different from technology in developed countries Health platforms will have to consider health from back end to front end The importance of designing for context of use, specifically in healthcare
Disagree/ void	All technical design components are not on the same level – points of parity vs points of differentiation Importance of developer documentation Prior to use of framework: establish type of application that can be developed using platform Platforms accommodate and secure different types of data (specifically healthcare) Platform security will have two components: internal and external to platform firm. Design for offline usage Design for device and for OS and version Diversity of data, especially in healthcare Different 'components' within a firm Two other things affect platform operation, scaling ability, evolution, R&D: (1) the size of the platform and (2) the maturity of the platform SOA – build components as black boxes Developer lock in – regarded as an entry barrier Think of usability in two dimensions: (1) developers and (2) end users Pricing options: licencing fee

"The absolute beauty of digital innovation is scalability. You build it once and can sell it 1 billion times. One coding team and it goes to everyone in the world." – Interviewee E

Concepts of the framework that were repeated throughout the interviews were the importance of modularity in the design approach, building the platform by means of several different software components and intentionally incorporating control mechanisms into the platform. In terms of the developers, platform and platform ecosystem barriers were important considerations. These barriers referred particularly to the programming languages, the availability of offline and online usage and having a community of developers. The platform design team should also focus on having an end-user mind-set, especially within a developing country such as South Africa and within the Health context. The rules and regulations within the health landscape were also emphasised.

"The platform is a lot of components: the UI, push notifications, offline functionality, and user-authentication – all independent components."- Interviewee A

"*In healthcare there is complexity of different regulatory aspects: if you use a thermometer and iPhone app. For example, if you use temperature reading for fever or ovulation – both has different regulatory aspects."* – Interviewee F

A key disagreement that was highlighted within the platform and governance design section is that the technical design components cannot all be compared on the same level. Some concepts can be seen as points of parity and others as points of differentiation as previously discussed in Section 7.5.2.1. In other words, certain concepts will enable the platform to stand out amongst competitors whereas others are simply a "ticket to the game". This categorisation will be noted in further research.

"There are points that make you stand out over your competition, and then there are others that are simply a ticket to the game. If you are not stable enough, people are not going to use you. But if you are stable, you are not going to win prizes."- Interviewee A

Several new insights were obtained with regards to the developers using the platform. Developer documentation, developer lock-in and usability for both end users and developers were some of the additional entry barriers that were identified. Lowering unwanted entry barriers and maintaining the desired entry barriers, are key balancing decisions that platform owners need to make.

"One of the biggest hurdles is documentation. The platform may be able to do anything, but it is not well documented."- Interviewee G

"A developer is a species on his own. You must give him freedom and creativity without allowing him to diverge from the plan." - Interviewee D

"If you are trying to develop a platform that has innovative things you need to create ways to allow for other innovative people to feed into that and the way you do this is by lowering the entry barriers." – Interviewee F

A factor that was not comprehensively included in the framework and that relates to both the platform and the developers using the platform is platform security. Comprehensive platform security mechanisms are vital for platform and platform ecosystem operation and success. Security can be segmented into security features to be implemented internal to the platform firm as well as security features protecting the platform from external factors. Security should therefore form one of the modular organisational components or teams within the platform firm with dedicated staff and processes.

"We have internal processes that tries to avoid that we get exposed to [platform] security loopholes; code review, user acceptance testing, Q&A within features. There are constantly new vulnerabilities that comes up with new technologies and that requires new functionalities." – Interviewee A

The interview data also yielded valuable insight into designing and implementing a platform in a developing country context. Components such as the diversity of data that should be accommodated on and through the platform, designing for offline usage, for particular hardware devices and for operating systems are factors that should be considered. The platform design team should be aware of the context of their end users and design for connectivity, for data usage, for limited digital literacy and for user acceptance. Specific rules and regulations enforced by governments should also be a key focus of the platform owner and compliance should be pursued in all dimensions of the platform development process.

"We catered for the local context from a technological perspective. We designed around availability of data, how to make sure the app is so small so that they can download it, the app also uses as little data as possible. We enabled more functionalities for offline usage. People also use older devices and older browsers, therefore we have to cater for every browser in the last ten years."- Interviewee B

"In SA 80% is still on prepaid and spending minimal on data. Therefore the whole way to structure the infrastructure (technology plus pricing) is completely different (to developing countries)."- Interviewee C

Part 4: Managing and operation

The managing and operation section of the interviews aimed to investigate the concepts that relate to managing and maintaining the platform and the ecosystem once it is operational. The summarised validations, disagreements, voids and additional insights are shown in Table 46 for easy reference during the discussion. Table 46 is drawn from Tables 40, 41 and 42.

Table 46: Summary of validations, disagreements, voids: Managing and operation section

Component	Managing and operation
Validated themes	Internal platform has more control Scalability of digital Control and monitoring Sustainability plan Scaling plan
Disagree/ void	Network effects dependent on size Support will differ between internal and external platforms Automated testing to monitor platform health Monitoring of apps in an internal platform Sustainability in terms of: (1) business and (2) technology Network effects not necessarily as prevalent in healthcare

"In healthcare you are not in an environment where you can accept failures - it has to work all the time."- Interviewee H

The interview data confirmed the advantages of digital technology and the ability to scale rapidly once the technology has been deployed. However, with this scalability there should be defined control, monitoring and evaluation mechanisms implemented in the platform and throughout the ecosystem. The platform owner should also have a clear sustainability plan covering the technology, ecosystem and especially the funding dimensions. Control enforced on developers should be carefully balanced as to not limit their ability to innovate, whilst maintaining the desired quality of the outputs.

"The big thing that we say is that if you want to build something [software], then you can get two types of tools: (1) total control over every detail that you want to build and the other side (2) where you have no control over the details, but you can do things on a specific level. We try to balance it between those two extremes."– Interviewee A

One of the most important processes during this stage of platform development was to provide adequate support, especially in the health landscape where failures are unacceptable. Support should typically be provided in three dimensions. The first dimension refers to internal platform support. This refers to the support provided for internal developers or employees working on the platform. Secondly, there should be a dedicated support team for external developers. The final support dimension refers to end-user support. These ecosystem actor support groups should typically be separated within the platform firm. It is therefore also clear that the support structure will differ for an internal platform firm and for an external platform firm.

"We have two teams: a platform team and a solutions team. The platform team provides support for the solutions team. In an external platform you would have to provide support for the external [developers] as well."– Interviewee A

Two aspects were not considered by the researcher particularly within the health context in a developing country: (1) strategies for introducing the platform into the market and (2) harnessing network effects once the platform is operational. Due to the differences in the health offering in developing countries, health platform firms may not be able to partner with medical aids or other partner ventures typically pursued in countries such as the United States of America or the UK. This results in a need for creative methods of market entry and formulation of partnerships. Once the platform is operating successfully, network effects would typically be expected. However, based on the nature of the platform particularly within the sensitive HC environment, the presence of network effects may not be predominant.

"With health it is a bit hard to get word of mouth going. No one is going to say yay I had diarrhoea and used this cool app, it's not one of the things you share." – Interviewee B

"Most platforms in the US have grown with partner ventures. They would add it as a benefit to their employees. Whereas in SSA, insurance is less common and employers do not really take care of their employees in the same way, so basically getting into the market differs a lot." - Interviewee B

Part 5: Evolution

The final section to which the data could be related was the evolution of the platform and ecosystem. Similar to the previous sections, the validations, disagreements and voids from the evolution section of Tables 40, 41 and 42 are summarised in Table 47.

Table 47: Summary of validations, disagreements and voids: Evolution section

Component	Evolution
Validated themes	Continuous learning curve Feedback forms a crucial part of the evolution and in developing the platform
Disagree/ void	Internal platform: app life cycle should be considered in terms of support, security and risk management Competition is not always the best benchmark - look at other industries as well Follow the trends of large, influential firms in the industry, not necessarily the competitors Look at trends specifically in programming (frameworks, languages that are better for specific uses) Also look at maturity of technologies before implementing (e.g. chatbots)

"As a start-up, feedback is critical. Our many pivots have all been driven by feedback."- Interviewee B

The evolution of the platform and ecosystem are iterative processes with continuous learning curves. A key instrument for evolution is to enable feedback from all ecosystem participants. This feedback should be considered and implemented in the platform or its complementary products, services or technologies based on its usefulness and priority.

"When I launched it in Kenya, it went through iterations, how do we gain trust in the market, how do we adapt to patient behaviour. We started with just an app, but eventually moved to in-pharmacy kiosk because we realised that people were more comfortable in a kiosk and pharmacy they trusted."- Interviewee B

The framework emphasised the constant monitoring of competition and the external environment of the platform and ecosystem as a method of evolution. Some of the interviewees disagreed with this approach and argued that focusing on competition may not be the best way to evolve the platform. The suggestion was that a platform owner should rather look at other industries and at large, influential firms in the industry as sources for evolution. Trends specifically in the programming landscape, referring to programming frameworks and industry standards and norms, should also be monitored. In addition, the maturity of possible technologies should be considered before implementing it in the platform and its products, services or technologies.

"Do not have a blind spot regarding your competition. For example, if the competition has a better technology and moves into your niche market, then they will dominate you." – Interviewee B

"I don't think looking at competition is a good way of evolving a platform, but looking at the other businesses in the industry. Look at other businesses in the industry. Look at bigger companies and look what they adopt - if they adopt, people will follow." – Interviewee H

The data from the interviews resulted in the identification of several additional concepts and insights that should be added to the framework in its attempt to be as comprehensive and generalised as possible.

Additional concepts

The additional concepts were derived from three sources, namely the disagreements or voids (D), and the additional insights (AD) identified in Tables 40 to 42 as well as concepts that emerged from further insight into the context of the framework. A total of 26 additional concepts were added to the framework. Five additional concepts came from further research and understanding and the remaining 21 from the interview data. These concepts, their descriptions and sources (referring to Tables 40 to 42) are included in Table 48. The tabulated additions will form a part of the conceptual modifications of the framework discussed in the following section.

Table 48: Interviews: Additional concepts added to the framework with descriptions and sources

Ecosystem level	Additional concept	Description	Source
Platform owner	Interoperability	The platform should be interoperable with other systems and/or software, particularly in the health landscape.	AD21
	Application type	The platform owner should determine in what form the end products, services or technologies will be made available to end users.	D7
	Data types	Various data types exist and the platform owner should be aware of the different classifications of data types it would encounter and how these should be interpreted.	D20
	Key activities	Determine the key activities that are required to realise the core functionality and interaction. This may refer to technology, connectivity, storage, etc.	D21
	Core functionality	The main functionality or functionalities that the platform aims to implement and achieve	Insight
	Financials	All financial aspects to be considered: financial investments required, donor funding, ecosystem value distribution.	AD26
	Key actors	The key actors required to realise the platform and its core functionality and interaction.	AD4
	Ecosystem health	The platform and ecosystem's definition of health and how will it be monitored for each ecosystem component.	Insight
	Key resources	The core resources in terms of personnel, HW, SW, access that is required to implement the platform and form and orchestrate the ecosystem.	D21
	Life Cycle	Identifying the life cycle stage of the platform and evaluating the effect on the management strategy.	D1
	Platform security	The specific security precautions that should be implemented in the platform to protect it from both internal and external developers.	AD12
Developer	Documentation	Supporting documents that assist developers in using the platform and indicate its functionalities.	D6
	Standards and protocols	The platform should aim to follow well-known industry standards and protocols.	D27
	Support	Adequate support for internal and external developers should be provided by the platform owner.	D34
	Usability (learnability, understandability)	The usability of the platform and its interfaces should be considered not only for end users, but also for the developers using the platform.	D31
	Pricing strategy	The monetary considerations relating to the developers using the platform.	AD7
	Envelopment	Refers to the platform 'swallowing' the functionalities of eternal developers in an attempt to evolve the platform.	Insight

Ecosystem level	Additional concept	Description	Source
	Industry-specific resistance	Resistance to implementation and adoption that relates to the specific industry.	D3
	Attraction	Refers to the ways in which developers will be attracted to the platform and ecosystem.	D4
	Data governance	The considerations relating to data storage and data ownership between the developers and platform owner.	AD12
	Design guidelines	There should be clear design guidelines to guide developers and also act as control mechanisms enforced by platform owners.	Insight
End user	Accessibility	Refers to how the end users will gain access to the end products, services or technologies.	Insight
	Data quality	The core functionality might include the acquisition and use of specific data. The data obtained from end users might have to be in a specific format or of a certain quality.	AD24
	Support	There should be support provided for end users. This can be in-app or in the form of a support centre.	AD11
	Data privacy and security	The end-users' privacy should be prioritised and their data secured.	AD12
	Data governance	The access and storage of the end-user data should be determined.	AD12

7.2.5.3 Third cycle coding

The third and final cycle of coding yielded themes, patterns and deeper insights into the data building on the outcomes of the previous two cycles. In the previous two cycles there were certain topics that featured continuously throughout the interviews. These were identified as trends and patterns that should be considered when designing, developing and implementing a technology platform in the South African health context and are summarised in Table 49.

Table 49: Trends and patterns identified during third cycle coding

Overarching category	Trend/pattern	Description
Ecosystem	Create user personas for ecosystem actors	Clearly define all needs and characteristics of all ecosystem actors. Link to value creation.
Platform design	Modular architecture	Platforms embedded in platforms.
	Interoperability and value of data in Health	In order to harness the value behind health data, platforms should be interoperable.
	Type of platform influences design	The platform profile should therefore be established prior to platform use.
Monetary	Platform core tailored pricing strategy	The pricing strategy adopted by the platform owner should be linked to elements of the platform core part.
	Funding is key for sustainability	Large amounts of investments are needed to ensure platform and business sustainability.
Developer	Developers are very concerned about entry barriers	Developers have certain aspects that they regard as entry barriers and this affects the platform they choose to join.
	Developer support dimensions	Developer support should be segmented in internal and external developer support. Internal refers to documentation and external to communities
Platform owner	Split the platform owner firm into discrete teams	Also modular nature of platform firm in terms of teams. For example separate support, control and design teams within the firm.
	Balance of control within platform ecosystem	The platform owner should be aware of the fine balance between too much and too little control.
South African context	Design and implementation considerations specifically for the SA context.	Designing and implementing a platform in the South African context requires several design constraints and concerns.

Overarching category	Trend/pattern	Description
Health context	Design and implementation considerations specifically for the Health context.	Designing and implementing a platform in the health context requires several design constraints and concerns.

The first trend that was identified throughout the interview data was to identify the actors in the ecosystem and design and manage the platform and ecosystem accordingly. This can be done by creating a user persona for each actor in the ecosystem. This breakdown of each actor should focus on what they deem valuable and how they can add value to the ecosystem. It should be done prior to the platform design in order to incorporate the insights of each actor into the design and governance of the platform and ecosystem.

The second set of trends related to the design of the platform. This included its modular structure, interoperability and establishing the platform profile prior to the design. The modularity was interpreted in two ways: (1) design the platform architecture by segmenting it into smaller pieces and (2) following a Service Oriented Architecture (SOA) approach where each aspect of the platform is created to be a black box and interfaces though APIs. The first interpretation refers to breaking down the overarching functionality of the platform into smaller, less complex pieces and designing each piece separately. The second interpretation is the implementation of an SOA which allows for each black box of the platform to function on its own and not be affected by changes in another black box. Therefore this supports adoption of a modular approach to simplify the complexity of a platform. Interoperability specifically for health-related data was highlighted in the interviews. This substantiates the recommendation of using existing, well-known frameworks, standards and protocols in the industry. The final platform design trend was that the nature of a platform affects how several of the concepts in the framework are approached and implemented. Subsequently, the researcher concluded that the platform profile should be determined prior to viewing the framework concepts.

The following sets of trends referred to monetary aspects of a platform, the developers and the platform owner. Firstly, it was clear that the platform pricing strategy should align with its core purpose and ecosystem actors' personas. The necessity of large amounts of funding for sustainability, particularly for external platforms, was also mentioned several times. The entry barriers for developers as well as developer support were also common points of discussion. Entry barriers can manifest in many different forms and a platform owner should be aware of the intended and unintended entry barriers of his platform and ecosystem. It could also be concluded that developer support should be facilitated in two dimensions: (1) internal support in the form of documentation and communication channels and (2) external support in terms of online communities and support groups. The next set of trends referred to the platform owner and how the platform owner's firm would typically function best when split into distinct teams. These teams could include separate support, design and development teams. This is particularly useful when the platform developers are both internal and external to the platform firm. The interviews also magnified the balancing act that platform owners have regarding the openness of the firm.

The final two trends related specifically to the South African and health contexts. Both these contexts have significant effects on the platform design, development and implementation and should be emphasised in the framework. Specifically South African health-related aspects were highlighted in the interview data. These aspects included the regulatory authorities and standards within the South African health context. Integration and interoperability of data and other software systems are also a very real issue in this landscape. Gaining access to data and using data that are currently operating in siloes poses significant challenges. The sensitive nature of this data should also be on a platform owner's priority list. Referring to the deployment, management and operation of a health platform in South Africa, platform owners should be aware of the levels of literacy and digital literacy of the end

users. They should also be aware of the typical standards and functionalities of the hardware devices that the target end users have at their disposal, as well as the cost and availability of data in their typical operational contexts. These factors all affect the platform design and management approach.

After taking the validated concepts, voids and disagreements, additional concepts and trends into account, the framework was modified accordingly.

7.2.6 Modifications to the framework

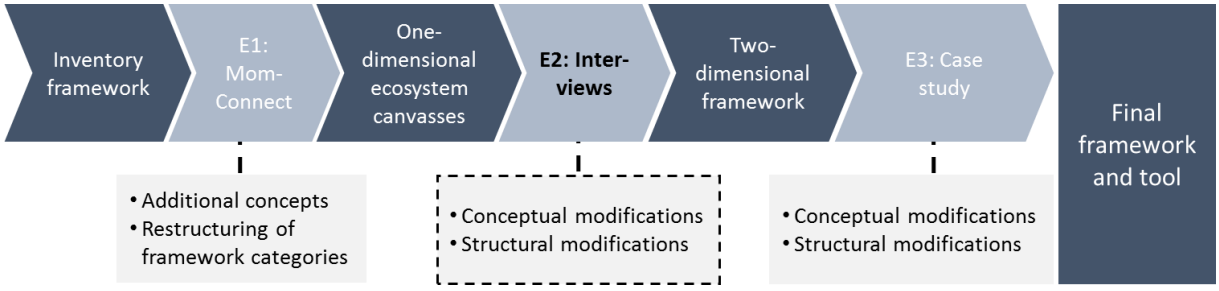


Figure 76: Context of framework modification and evolution: E2

Two sets of modifications were done to the framework, namely conceptual modifications and structural modifications. Conceptual modifications refer to any additional insights that lead to additional concepts or changes in concept descriptions. Structural modifications refer to physical changes in the framework layout. The context of the modifications as a result of the interviews (E2) are shown in Figure 76. These modifications were inspired by either the voids or disagreements highlighted from the interview data, or from increased understanding into certain concepts (referred to as 'logic' in Table 50). The additional concepts from Table 48 were also included as conceptual modifications. The modifications with their motivations and references are shown in Table 50.

Table 50: Interviews: Modifications to the framework with descriptions and references

	#	Modification	Motivation or description	Reference(s)
Conceptual	1	Several concept additions/redefining	Additional concepts were added to the framework as identified from the data	Table 48
	2	Emphasising support and control and its dimensions	Emphasis was placed specifically on the control and support components throughout the framework	AD11, D34
Structural	3	Add first page canvas to establish the platform profile	Prior to platform use, the platform profile should be determined as it affects the interpretation of the framework	AD10, AD11, AD6
	4	Developer canvas: Control and support subcategories adjusted	A better understanding of the control and support and additional concepts inspired a new arrangement	AD11, logic
	5	End-user canvas: Control and interface subcategories adjusted	A better understanding of the interface and design and the additional concepts inspired a new arrangement	Logic
	6	Add five platform development parts to framework as a second dimension	The five phases were not yet a part of the framework. The initial purpose was merely to simplify the interview process. These parts, however, give more depth and context to the framework	AD5, AD7, AD10, AD4, AD2, AD23, AD30, AD22, AD14, AD13
	7	Redefine ecosystem canvasses (initial framework) as dimension one	Following the addition of a second dimension, the three ecosystem canvasses were grouped as dimension one	Formulated two dimensions

	#	Modification	Motivation or description	Reference(s)
	8	Added to dimension one canvasses: definition of actor, key considerations	In order to better understand each ecosystem actor and their focus, a concise definition and focus areas were added to the top of each canvas	Done to avoid confusion
	9	Add an overview canvas to link the two dimensions	Based on the Excel sheet that was used to initially group the concepts for the interview process (see Figure 69), a canvas was added that links the two dimensions	Link two dimensions
	10	Adding a section on SA Health in dimension two canvas	It was added based on the insights from the data and the objectives of the framework to be applicable for SA and Health	AD17, AD15, AD16
	11	Adding section on research areas in dimension two canvas	The section is to emphasise the multidisciplinary nature of the framework. This was emphasised by the systematic review in Chapter 3.	Chapter 3

The resulting framework now comprised a total of six canvasses. The first canvas was the Pre-use Canvas that aimed to establish the platform profile prior to using the framework. The next three canvasses were the Ecosystem Canvasses. These canvasses comprised the original framework which relates to the platform owner, developer and end user. The fifth canvas was defined as the Platform Development Canvas. This canvas comprised of the five parts identified initially for simplifying the interviews. The additional insights obtained from the interview data that could not be added to the ecosystem canvases were compiled into the Platform Development Canvas. This canvas also focused on incorporating the additional five lenses that were identified during the interview data coding cycles. These lenses include health, South Africa, control, support and financing and pricing. The sixth and final canvas was the Overview Canvas which indicates how these two dimensions relate to one another. This evaluated and adapted framework is discussed next and the A3 canvasses are included at the end of this chapter.

7.3 The evaluated and adapted framework

The evaluated and adapted framework follows from the investigation of the MomConnect initiative and the concept validation through semi-structured interviews. The canvasses in the evaluated and adapted framework and how they relate to the two dimensions are shown in Figure 77 on the next page.

* *Please note that the text included in the canvasses (for both the evaluated and adapted framework and final tool) are meant to be concise and are therefore not always complete sentences. The focus was to keep all sentences as short as possible while still conveying the significant ideas and accomplishing the intended purposes. Also, there are some similarities between the evaluated and adapted framework presented in this section and the final framework in Chapter 9. The detailed discussions of elements included in both framework iterations will be included in Chapter 9 with the final framework discussion*.

The Pre-use Canvas highlights the importance of establishing the platform profile prior to the use of the final tool. The reasons for establishing the platform profile are to determine the lens and approach towards the framework and its concepts. Four aspects are to be considered by the platform owner before using the tool: (1) platform type, (2) noting whether the platform is an internal or external platform, (3) identifying possible distribution channels and contexts and (4) the desired application industry. These platform profile considerations and their effects on framework use and interpretation

are indicated in Table 51. The Pre-use Canvas also gives an overview of the breakdown of the framework and the aim of each canvas.

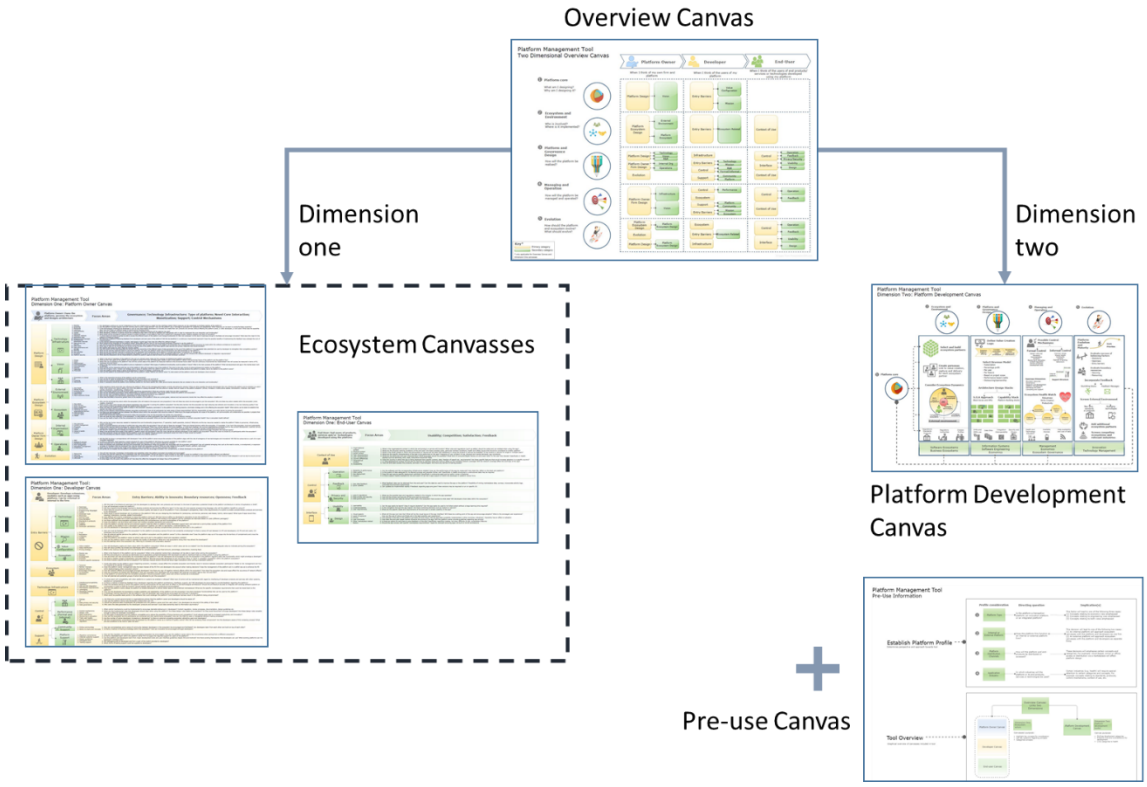


Figure 77: An overview of the framework dimensions and canvasses

Table 51: Platform profile elements and their effects on use of the framework

Platform Profile consideration	Effect on use
Platform type	This decision will lead to one of the following three cases: 1. Concepts relating to economic view emphasised 2. Concepts relating to engineering view emphasised 3. Concepts relating to both views emphasised
Internal or external platform	This decision will lead to one of the following two cases: 1. Internal platform will approach ecosystem canvasses as platform and developers as one firm 2. External platform will approach ecosystem canvasses as platform and developers as separate firms
Distribution channels and contexts	These decisions will highlight certain concepts and categories as more important. For example: cloud-based, online or offline access or distribution via a Marketplace (Appstore, for example)
Application industry	Certain industries (e.g. health) will require special attention to certain categories and concepts. For example relating to standards, protocols, control mechanisms, context of use etc.

The Overview Canvas will be discussed first, followed by the three Ecosystem Canvasses. Thereafter the Platform Development Canvas will be discussed. The actual full-sized canvasses are included after the following discussion.

7.3.1 Overview Canvas

The Overview Canvas presents the two dimensions of the framework and how they link with one another. The first dimension refers to the ecosystem actors which comprise the platform owner, developer and end user. The platform owner column of the canvas demands the platform owner to

think of his own firm and platform. The developer column considers what the platform owner should think of regarding the users of his platform. The final column refers to the end users and requires the mind-set of the users of the end-products, services or technologies developed using the platform.

The second dimension includes five platform development categories, namely the platform core, the ecosystem and environment, platform and governance design, managing and operation and evolution. The platform core refers to the 'what' and 'why' questions of the platform. This will form the foundation of the platform design, development and implementation. The second category refers to the ecosystem and environment and aims to answer the 'who' and 'where' questions regarding the platform and ecosystem. This category not only considers the platform ecosystem, but also the external environment and its effects on the platform and platform ecosystem. The third category is platform design and governance design which aims answer the 'how' questions regarding the design of the platform. This section considers how the platform will practically be designed and implemented. The fourth category refers to platform managing and operation and it aims to guide the platform owner through considerations on how the platform and ecosystem could be managed and operated. The final category is the platform evolution which focuses on how the platform should evolve and which aspects of the platform or ecosystem should evolve.

The Overview Canvas has the following layout: The columns refer to each of the ecosystem actors respectively. The rows refer to each of the platform development categories respectively. The intersection of the rows and columns result in fifteen blocks which represent the main categories derived from the ecosystem canvasses and decomposed into subcategories where applicable.

7.3.2 Dimension One: Ecosystem Canvasses

The purposes of the three Ecosystem Canvasses are to highlight key concepts for consideration, to ask key questions regarding these concepts and to categorise these concepts into high level categories. The desired approach towards these canvases are for the platform owner to 'put on the hat' of each ecosystem actor and thereby aim to understand what should be incorporated or managed with regard to the platform or platform firm for each actor. Each Ecosystem Canvas includes five components: (1) a simple definition of the ecosystem actor, (2) core focus areas to consider regarding that actor, (3) main categories on the left-hand side which are decomposed into one or two sub-levels, followed by (4) the numbered concepts related to that category and (5) corresponding key questions which are numbered accordingly. The Ecosystem Canvasses are included at the end of this chapter.

7.3.2.1 Platform Owner Canvas

The focuses of the Platform Owner Canvas are the technology platform itself and the platform owner firm, who governs the ecosystem and designs and maintains the technology platform. The main focus areas of this actor are their responsibility for governance, the technology infrastructure, establishing the desired type of platform with a novel core interaction, monetisation, support and control. The canvas is divided into four main categories including platform design, platform ecosystem design, platform owner design and evolution. Platform design considers the design of the technology infrastructure, the platform vision and rules and regulations. Platform ecosystem design is split into concepts relating to the external environment and concepts relating to the platform ecosystem itself. The platform owner design category refers to the platform owner firm and also has two subcategories. These subcategories are the internal organisation of the firm and operations required within the platform firm. The final category of this canvas relates to evolution.

7.3.2.2 Developer Canvas

The focus of the Developer Canvas is to highlight concepts that a platform owner should consider to enable developers to fulfil their role of developing extensions, modules and applications using the platform. Depending on the internal or external nature of the platform, the developers will be a part

of the platform firm, or be external parties. Focus areas of the developer canvas are possible entry barriers, enabling innovation, boundary resources, openness and feedback mechanisms. The canvas is divided into five main categories, namely entry barriers, ecosystem, technology infrastructure, control and support. As with the Platform Owner Canvas, these categories were chosen according to key focus areas identified regarding developers. Entry barriers are further divided into barriers relating to the technology, the platform's mission (how platform and firm are perceived), the value configuration and ecosystem aspects. The control category is also subdivided into rules and regulations and performance control through formal and informal control mechanisms. The final category, support, is further broken down into community support and platform support categories. Both these categories were emphasised during the semi-structured interviews.

7.3.2.3 End-user Canvas

The End-user Canvas relates to the end users of the products, services or technologies developed using the platform. This canvas comprises three main categories namely context of use, control and interface and design. The control category subcategories include operation, feedback and privacy and security. The End-user Canvas formed the final Ecosystem Canvas of the framework.

7.3.3 Dimension Two: Platform Development Canvas

The main aims of the Platform Development Canvas are to outline main platform development categories, to present tools and considerations for this development and to link the development categories to considerations in South African health context. These could all provide a platform owner with insight into developing the platform and ecosystem. The canvas commences with the platform core section and four subsequent columns, for each of the remaining platform development parts respectively. This illustrates that the trajectory for the remaining four parts are established by the initial platform core. The canvas layout includes three elements: (1) the platform development part populated with practical tools and insights regarding that category, (2) considerations for health in the South African context at the bottom of each column, and (3) specific literature groups relevant to each category which are included as separate columns at the bottom of the canvas.

The complete evaluated and adapted framework with all the above-mentioned canvasses is included after the Chapter 7 summary. As mentioned previously, a more detailed discussion on similarities between the framework presented in this chapter and the final tool is included in Chapter 9.

7.4 Chapter 7 Summary

The main outcome of chapter 7 was the evaluated and adapted framework. The evaluated and adapted framework followed from the semi-structured interviews. Semi-structured interviews were conducted with local and international experts and the interview data analysed to evaluate, modify and adapt the framework. The resulting framework comprises two dimensions, namely the ecosystem dimension and the platform development dimension. Chapter 8 will present the final evaluation phase which includes a case study on Mezzanine Ware.

Evaluated and Adapted Framework: Pre-use Canvas

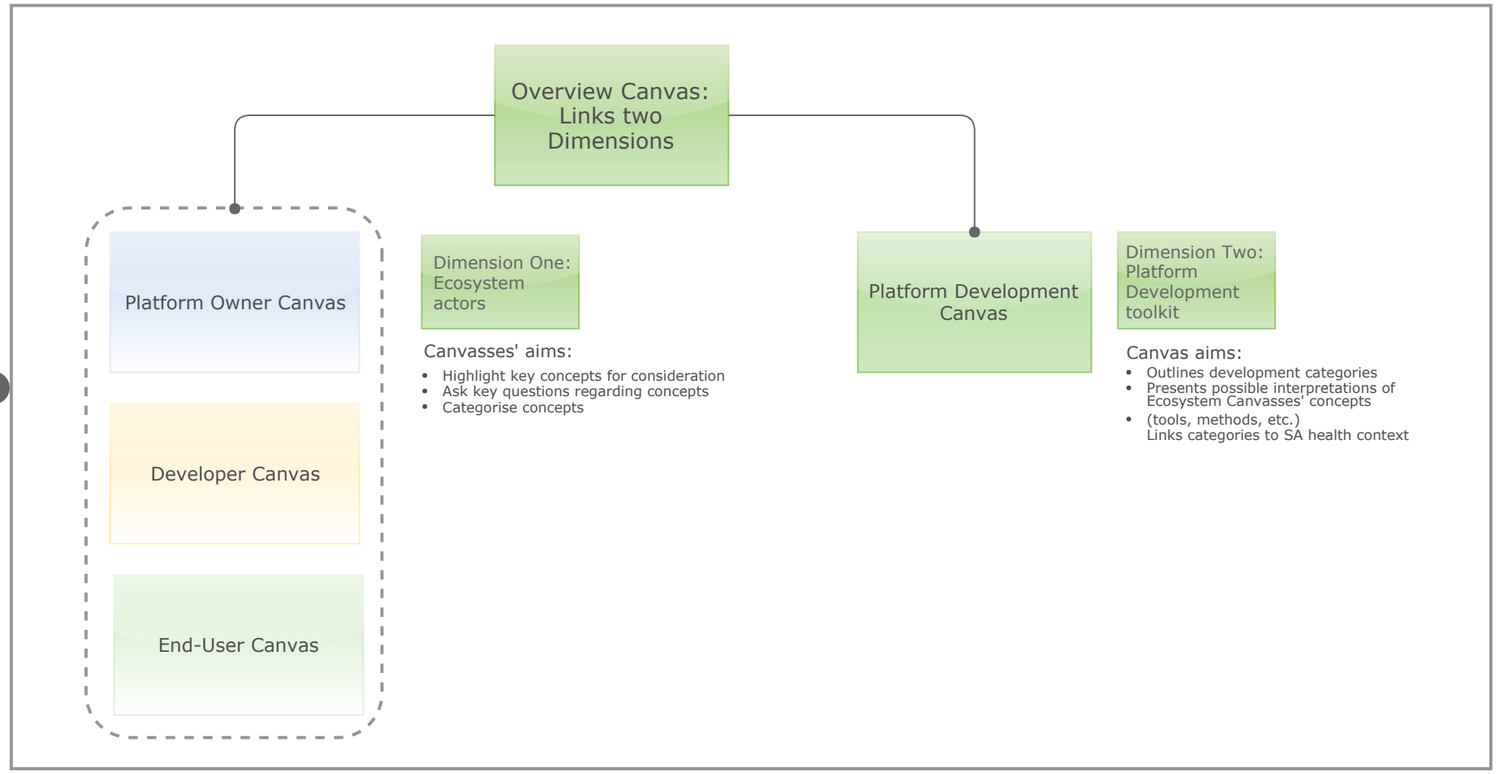
Establish Platform Profile

Determines perspective and approach towards tool

	Profile consideration	Directing question	Implication(s)
1	Platform Type	Is the platform a transaction platform,an innovation platform or an integrated platform?	This factor will lead to one of the following three cases: (1) Concepts relating to economic view emphasised (2) Concepts relating to engineering view emphasised (3) Concepts relating to both views emphasised
2	Internal or External Platform	Does the platform firm function as an internal or external platform firm?	This decision will lead to one of the following two cases: (1) An internal platform will approach ecosystem canvasses with the platform and developers as the same firm (2) An external platform will approach ecosystem canvasses with the platform and developers as separate firms
3	Platform Distribution Channels	How will the platform and end-products be distributed or accessed?	These decisions will emphasise certain concepts and categories. For example: cloud-based, online or offline access or distribution via a marketplace will affect platform design
4	Application Industry	In which industries will the platform or its end products, services or technologies be used?	Certain industries (e.g. health) will require special attention to certain categories and concepts. For example concepts relating to standards, protocols, control mechanisms, context of use, etc.

Tool Overview

Graphical overview of five canvasses included in tool



Evaluated and Adapted Framework: Two Dimensional Overview Canvas

1. **Platform core**

   What am I designing?
   Why am I designing it?

2. **Ecosystem and Environment**

   Who is involved?
   Where is it implemented?

3. **Platform and Governance Design**

   How will the platform be realised?

4. **Managing and Operation**

   How will the platform be managed and operated?

5. **Evolution**

   How should the platform and ecosystem evolve?
   What should evolve?

Key*

- Primary category
- Secondary category

* only applicable for Overview Canvas and Dimension One canvasses

Platform Owner	Developer	End-User
When I think of my own firm and platform	When I think of the users of my platform	When I think of the users of end products/ services or technologies developed using my platform
Platform Design – Vision	Entry Barriers – Value Configuration, Mission	
Platform Ecosystem Design – External Environment, Platform Ecosystem	Entry Barriers – Ecosystem Related	Context of Use
Platform Design – Tech Infrastructure, Vision, R&R Platform Owner Firm Design – Internal Org, Operations Evolution	Tech Infrastructure Entry Barriers – Technology, Mission Control – R&R, Performance Support – Community, Platform	Control – Operation, Feedback, Privacy/Security Interface – Usability, Design Context of Use
Platform Design – Infrastructure, Vision	Control – Performance Ecosystem Support – Platform, Community Entry Barriers – Mission, Ecosystem	Control – Operation, Feedback Context of Use
Platform Ecosystem Design – Ecosystem Evolution Platform Design – Vision, Tech Infrastructure	Ecosystem Entry Barriers – Ecosystem Related Infrastructure	Control – Operation, Feedback Interface – Usability, Design

Evaluated and Adapted Framework:
Dimension One: Platform Owner Canvas

Platform Owner: Owns the platform, governs the ecosystem and designs architecture

Focus Areas

Governance; Technology Infrastructure; Type of Platform; Novel Core Interaction; Monetisation; Support; Control Mechanisms

Platform Design	Technology Infrastructure	1. Stability 2. Scalability 3. Modularity 4. Interfaces 5. Interoperability 6. Toolkit 7. Openness 8. Feedback methods 9. Application type 10. Programming languages 11. Marketplaces/ distribution channels 12. Data privacy and security 13. Data types 14. Data governance and storage 15. Security 16. Key activities 17. Providers 18. Platform security	1. Can developers continue as normal if alterations to the core platform are made? Are the interfaces stable? What measures can be undertaken to facilitate stability of the platform? 2. Can the platform function equally well with minimal users as with a large demand? How can the platform use or leverage its ecosystem for scalability and adaptability? What measures can be taken to enable/facilitate scalability? 3. Is the platform technological infrastructure developed in such a way that it enables developers to innovate and create their own products and services without affecting the platform owner firm, other developers or end users? What does the tech stack look like? What are different levels of infrastructure (building blocks)? 4. What will the interfaces comprise? What APIs or standard interface protocols will be used/can be used? 5. What standards, protocols or policies should the platform align with or be able to interface and interoperate with, in order to implement the core interaction and functionality? 6. What toolkit will be provided to external parties to enable innovation on the platform? Will such a toolkit aid in developer loyalty, platform adoption and level of innovation? 7. To what extent will external parties be able to access the different layers of the platform and change functionality for their own purposes? Is this level of openness enough to facilitate and encourage innovation? What does this mean for the software platform design? 8. Will there be a method of obtaining feedback from developers and end users of the platform? Will this be beneficial in a continuous improvement approach? Does the possible benefits of implementing this feedback loop outweigh the cost of implementation? 9. Is the desired extension/application a mobile, web-based or hybrid app? How does this affect the software platform design? 10. What programming language will the platform adopt? What is the effect of the programming language on developer attractiveness? 11. How will the products developed on the platform be distributed? Will the end-products of the platform be distributed via a marketplace? Should provisions be made within the software platform to enable this distribution? 12. What type of data will be transferred and stored during the use of the platform? Are there specific data security and privacy measures that should be taken? 13. Will specific data types be used? These might be industry related (specifically in HC) 14. How and where will the data generated be stored? Who has ownership of the different types of data generated by the use of the platform? Can aggregated data be used by developers to strengthen their competitive position? 15. What are the security measures taken to secure the platform, its users, the platform owner firm and all transactions and data generated by the platform? 16. What are the key activities required to achieve the core interaction and functionality of the platform? Includes technology, connectivity, IP, storage, etc. 17. What technologies will be used to implement the platform? In terms of HW and SW or other embedded platforms? How will this influence the software developed or integration requirements?' 18. What security precautions will be implemented to protect the platform against external factors such as bad developer practices?
	Vision	1. Scope 2. Goals 3. Measurement 4. Core functionality 5. Core interaction 6. Stability 7. Openness 8. Financials	1. What is the area(s) of platform operation? How will scope creep and the crossing of predetermined platform boundaries be prevented? 2. What are the main goals of the platform and the platform owner firm? How will these goals relate to users of the platform? 3. What KPIs can be applied to the platform? How will the current state of the platform be measured relative to the envisioned future state? How will continuous improvement be implemented? How will success be measured in terms of the platform owner firm, developers and end users? 4. What is the main function that the platform aims to implement or achieve? What types of additional functionality could be added in future? What is the main purpose of the platform? What gap in the market does it aim to fill? 5. What interaction(s) will be facilitated by the use of the platform? Who will innovate on top of the platform? This links to the main source of value exchange and creation on the platform 6. Does the company vision, mission and strategy give a sense of stability within the platform owner firm? Will external parties perceive the platform as stable, due to its association with the platform owner firm? 7. Does the platform owner firm adopt a sense of transparency? In terms of strategy, governance, etc. 8. How can the platform be sustainably funded? How will the platform create, capture and deliver value? To what extent will the platform owner firm and developers share revenue?
	Rules and Regulations	1. Proprietary vs shared 2. Intellectual Property 3. Licencing 4. Standards	1. What is the ownership structure of the platform and its components? 2. How can the IP rights be established to facilitate third party innovation and not limit it? 3. What will the licencing agreements, if any, between the platform owner firm and developers look like? 4. What IT standards should the platform and interfaces adhere to? Are there specific ISO, IEEE or governmental standards that are related to the core interaction and functionality?
Platform Ecosystem Design	External Environment	1. Key trends 2. Market forces 3. Industry forces 4. Competition 5. Value chain 6. Macroeconomic forces	1. What industry trends exist that may influence the platform? What are the emerging technologies currently disrupting the industry? What are other possible disruptive technologies that may influence the platform and its adoption? What is the cultural and natural setting into which the platform is being introduced? Will the culture or society have an impact on the platform adoption? (Africa). For example an increase in mobile phone uptake, individualism, millennial generation, new health policies, blockchain, crowd-funding, crowd-sourcing, etc. 2. Who is the target market and what are major identifying characteristics? What are customer needs that are typically unsatisfied? 3. Who are the competing ecosystems? What differentiates this platform and ecosystem? Why would parties choose this platform and ecosystem? 4. Who are the main competing platforms? Are there substitute products/services to the platform? 5. Who are the upstream and downstream stakeholders or actors that can be relied upon? 6. What does the effect of economic growth have on the adoption of the platform? What are current global, national and local economic trends that may affect the adoption of platforms?
	Ecosystem	1. Key actors 2. Entry barriers 3. Role in ecosystem 4. Responsibility 5. Technical and socio-organisational barriers 6. Decomposition 7. Decision rights 8. Ecosystem health	1. Who are the envisioned key actors within the ecosystem (this will relate to the scope and core proposition)? How will these key actors be encouraged to join the ecosystem? Why are these key actors needed within the ecosystem (niche creation, diversity)? 2. What are the major entry barriers that external developers may encounter in joining this platform ecosystem? Are the ecosystem entry barriers too high (thereby reducing new entrants and innovation) or too low (reducing quality)? How can a sense of control be applied through establishing entry barriers? 3. What role does the platform owner firm aspire to adopt in the ecosystem (keystone, dominator)? Is the platform owner firm leaning towards a dominator strategy and is this affecting the ecosystem health? What actions can be taken to establish the desired role within the ecosystem? 4. What are the different responsibilities between ecosystem participants? How will all participants be made aware of these responsibilities? Will this responsibility be seen as an entry barrier to joining the ecosystem? 5. Are there any technological barriers between the different actors within the ecosystem that should be noted? Will communication and collaboration be possible in projects that are geographically distributed? 6. What is the envisioned organisational structure within the ecosystem? How can the ecosystem be divided into subsystems? 7. Who will have the main authority in the ecosystem? To what extent will other participants have rights and authority to decision-making? 8. How can the health of the ecosystem be monitored and evaluated? What are the key relationships or components required to maintain ecosystem health? How is ecosystem health defined?
Platform Owner Firm Design	Internal Organisation	1. Key resources 2. Conflict management 3. Processes 4. Culture 5. Vision 6. Values and beliefs 7. Support	1. Who are the key human resources needed to implement the core functionality (programmers, IT specialists, health specialists, doctors)? What/who are the key resources needed to realise the platform? Refers to personnel, infrastructure, access, technology, etc. 2. What are possible tensions and areas of conflict that may arise within the ecosystem? How will each of these be managed? There are inherent tensions within the ecosystem, if it escalates, it can harm the ecosystem, trust and sustainability 3. What are the required internal processes for optimal platform functioning? These may include separate firm-level meetings, or ecosystem meetings. Are common organisational processes such as new product development, customer service, relationship management, etc., required within the platform owner firm? What plans and procedures can be put in place within the organisation to manage conflict/tensions/innovation? 4. Will the firm create a culture of debate and discussion? Does the company culture aim to deal with conflicts in a healthy manner? Does the company culture encourage innovation? 5. What is the envisioned future state of the platform, platform owner firm and ecosystem? Does the vision attract the desired participants to the platform and ecosystem? Should the vision be shared by all participants within the ecosystem? 6. Are there particular values and beliefs that the platform owner firm adopts? Should ecosystem participants adopt and share in these values and beliefs? 7. Who are providing the internal support, especially in the case of an internal platform?
	Operations	1. R&D 2. Support & services 3. Marketing & sales 4. Risk management 5. Reputation management 6. Investments	1. Will the R&D be done in correspondence with developers? How will the platform owner firm ensure that the evolution of the platform aligns with the rate of emergence of new technologies and innovations? Will R&D be outsourced as a part of an open innovation approach? 2. Is there an adequate, rapid-response, support structure for users of the platform? Will there be support available for new platform users? 3. What strategies can be adopted to encourage platform ecosystem growth? How will network effects be initiated? 4. What are possible risks associated with the core functionality and interaction? What are possible risks associated with the ecosystem participants? How will potential emerging risks (such as the need to evolve, or envelopment, or expansion of scope, or monetary risks) be monitored? Can risks be shared between ecosystem partners? What are risks related to that specific industry, partners or technology? 5. What can be done to improve the image of the platform owner firm and platform? How do others perceive the platform firm? 6. Will profits be re-invested into the platform firm and ecosystem? Can this encourage innovation from complements, or attract developers to the platform?
Evolution		1. Resourcing 2. Securing 3. Sustainability 4. Life cycle	1. How will new resources, knowledge, functionalities and capabilities within the platform ecosystem be enabled and encouraged? 2. Are there new security measures to be implemented with additional functionalities? Should the level of control exerted by the platform owner firm be modified? Is the control portfolio efficient and effective? 3. Is the platform firm as well as the platform designed for sustainability? Will the platform need to evolve to align with mandatory core-specific organisations/initiatives? Is the revenue model designed in such as way to ensure survival at each stage of the technology life-cycle? 4. At what stage of their life cycles are the platform and platform firm at? How do this affect the managerial and design focus of the platform and firm?

Evaluated and Adapted Framework:
Dimension One: Developer Canvas

Developer: Develops extensions, modules such as apps using platform. Can be external or internal to the firm

Focus Areas

Entry Barriers; Ability to innovate; Boundary resources; Openness; Feedback

Entry Barriers

Technology

1. Openness
2. Accessibility
3. Programming languages
4. Toolkit
5. Developer type
6. Stickiness
7. Homing costs
8. Documentation
9. Standards and protocols
10. Support
11. Usability
12. Developer satisfaction

1. Will the level of architectural openness limit the developers to develop their own products and services? Is the level of openness a potential threat to the platform architecture in terms of duplication or theft?
2. How will developers access the platform?
3. Will the programming language required to develop products and services be difficult to learn? In the case of a non-popular programming language, why will the platform benefit by using it?
4. What features should be included in a toolkit to ensure quality and ease of use of the platform? From a developer's perspective, what are the requirements of a toolkit to enable complementary products and services to be developed on the platform?
5. What would a typical developer aim to achieve on the platform? What type of app would developers develop (enterprise, commercial, personal, web-based, hybrid, native apps)? Further extensions, modules, added functionality?
6. How difficult will it be for a developer to leave the platform (lock-in)? Will this have an effect on a developer's motivation to join this platform?
7. What are the complete set of costs associated with joining the platform? Will access to the platform and its interfaces be restricted based on costs (different packages)?
8. Are there sufficient documentation available to describe the comprehensive use and functionalities of the platform?
9. Does the platform use and follow well-known and industry accepted standards and protocols?
10. Does the platform provide internal and external support? Internal refers to platform owner dedicated support team and external to communities outside of the platform firm
11. How usable is the platform from a developer's perspective? Usability can refer to learnability, understandability, etc.
12. Can the satisfaction of developers be measured? Is it enjoyable to develop complementary products and services on the platform?

Mission

1. Trust
2. Reputation
3. Credibility
4. Loyalty
5. Fairness

1. How can trust be fostered within the ecosystem? Is the platform owner firm conveying a sense of trust (not constantly enveloping)? Is there a sense of trust between (1) platform owner firm and developers, (2) platform owner firm and end users, (3) developers and end users?
2. How do external parties perceive the platform, the platform ecosystem and the platform owner firm? Is this a desirable view?
3. Do the platform and platform owner firm do what they set out to do? Are the platform brand and reputation credible?
4. How can the platform owner invest to maintain the loyalty of developers? What are rival ecosystems doing to attract developers?
5. Are the dealings within the ecosystem fair (referring to monetary and proprietary aspects)?

Value Configuration

1. Value creation
2. Value distribution
3. Pricing strategy

1. How will developers create and share value within the platform ecosystem? What are ways in which value can be co-created? Can the developers create adequate value to motivate joining the ecosystem?
2. How will value (profits) be divided and distributed throughout the ecosystem?
3. What is the revenue model and will it be beneficial for complementors? (pay fixed amount, percentage, subscription, licencing fees)

Ecosystem

1. Market size
2. Markets
3. Envelopment
4. Diversity
5. Industry-specific resistance

1. What are the footprints of the platform and its ecosystem? What is the potential market that a developer will be able to access when joining the ecosystem?
2. Will the end-products or services be distributed via an application portal/marketplace? Will developers be able to distribute freely on these portals if using the platform?
3. How and when will new functionalities be incorporated into the platform? How will developers be encouraged to join the ecosystem if the platform regularly adds functionalities which might envelope a developer?
4. Are there a healthy variety of developers using the platform? Will this encourage developers to join and share value, or result in unhealthy competition within the platform ecosystem?
5. Are there industry-specific barriers to adoption? For example medical doctors concerned about legal implications when joining a tele-health platform

Ecosystem

1. Tensions
2. Partner interests
3. Network effects
4. Encourage innovation
5. Co-evolution
6. Attraction

1. Could risks taken by the platform owner firm (regarding evolution, financial, scope boundaries) affect the complete ecosystem and thereby result in tensions between ecosystem participants? Relate to risk management and how it is shared by all parties in ecosystem
2. Does the platform owner firm take the best interests of both the themselves and developers into account when making decisions? Does the platform owner firm act in a selfish way and at the cost of other ecosystem actors?
3. How will network effects be encouraged amongst developers? Is there any sign of negative network effects within the ecosystem? How do the ecosystem size and scope affect the prevalence of network effects?
4. How can innovation be shared with developers? How can innovation from developers be encouraged? Will external innovation lead to less risk and increased R&D?
5. Are the platform and platform firm co-evolving with the complete ecosystem? Should ecosystem goals, vision and current markets be re-evaluated?
6. How will planned and potential groups of actors be attracted to join the ecosystem?

Technology Infrastructure

1. Interfacing/compatibility
2. Feedback
3. HW and SW integration
4. Marketplace requirements
5. Leveraging
6. Developer practice
7. Vulnerability

1. To what extent will compatibility with other platforms or systems be enabled or allowed? What level of control will be maintained with regard to interfacing of developer products and services with other systems, solutions or components?
2. Is there a method of obtaining feedback from developers regarding the platform architecture, interfaces, support, etc? Will developers be encouraged to provide feedback regarding the platform?
3. Do the hardware devices on which the platform and its end-products will be used have an effect on the platform design? Should the platform be able to integrate with existing software systems or components in order to fulfil its function? Should specific data formats or protocols be accommodated?
4. How can the platform owner firm design its platform to enable developers to deliver better apps at their preferred marketplaces? What are the specific marketplace requirements?
5. How can the developers be leveraged to enable scalability and adaptability of the platform and the ecosystem? Are there developer functionalities that can be used by the platform?
6. Is developer training required to use the platform? How will developer best practices be encouraged and enforced if necessary?
7. What could be possible weak points in the platform software that could endanger the platform? Could developer laziness compromise the platform security?

Control

Rules and Regulations

1. Policies
2. Intellectual Property
3. Data privacy and security
4. Data governance

1. Are there any current governmental or organisational policies that the platform owner and developers should be aware of?
2. How can the platform owner help developers protect their own IP?
3. Should the personal data of developers be protected from the platform owner and from each other? Can developers be ensured of the safety of their data?
4. Who owns the data generated by the developers' products and services? Could data ownership lead to information asymmetry?

Performance (Formal and Informal)

1. Control mechanisms
2. Design rules
3. Goal congruency
4. Monitoring and evaluation
5. Track user loyalty
6. Review process/content regulation

1. What control mechanisms could be implemented to encourage desirable behaviours in developers? Content regulation, review processes, documentation, design guidelines etc.
2. What are the fundamental rules that developers should obey when using the platform? Are these design rules stable and consistent? Do they avoid favouritism amongst developers? Are these design rules versatile enough to allow for developer innovation?
3. Are the goals of developers and the platform compatible (to reduce the possibility of future tensions and competition)? Could aligned goals lead to increased productivity and innovation?
4. How can the ecosystem and its participants be monitored and their performance evaluated? How can M&E be used in managerial decision-making processes?
5. Is the number of active developers increasing or decreasing? Is there an external competing ecosystem causing users and developers to migrate?
6. Will the complementary products/services be reviewed by the platform owner firm as a method of quality control? Who will be reviewing these components? Are the developers aware of this reviewing process? What are the conditions to be met to "pass the test"?

Support

Community Support

1. Online communities
2. Ability to share and innovate

1. How can connectedness and a sense of community between developers in the ecosystem be encouraged and facilitated? Can developers learn from each other and build on top of each other's products and services?
2. Is there a method of sharing knowledge within the ecosystem? How can innovation be encouraged amongst developers?

Platform Support

1. Migration convenience
2. Internal customer support
3. Design guidelines
4. Debugging aids
5. Testing support

1. How can the migration convenience from a competing ecosystem be encouraged? How can the platform owner firm add to the convenience when joining from a different ecosystem?
2. Is there a dedicated team within the platform owner firm to supply the required support for users of the platform?
3. Can the platform and developers learn from major development tools and user interface guidelines (such as Apple HIG and Android UI guidelines)? Are there existing software frameworks that developers can use? What existing platforms can the developers interface with?
4. Will debugging aids be developed and be a part of the toolkit provided to developers?
5. Which forms of testing support could be supplied to developers?

Evaluated and Adapted Framework:
Dimension One: End-user Canvas

End user: End users of products, services and/or technologies developed using the platform

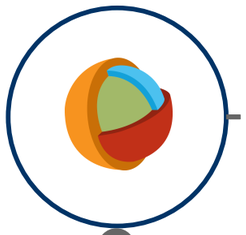
Focus Areas

Usability; Competition; Satisfaction; Feedback

Context of Use		1. Organisational context 2. Physical context 3. Social context 4. Task characteristics 5. User characteristics 6. Country differences 7. Geographical context 8. Accessibility	1. What is the organisational context in which the end-product or service will function? What rules and regulations (such as safety) should be noted and not violated when using the app? 2. What are the physical working conditions of the end user? Are there possible noise, particular ambient conditions or health and safety issues that would influence usability? 3. What is the social context in which the end-product or service will be used? Will assistance in using the product or service be available? Is the product or service for single or multiple users? 4. What are the specific characteristics of the task to be performed? Frequency of use, duration of use, physical and mental demands, app complexity 5. What are the particular end-user characteristics? What languages should be available? What level of computer/digital literacy do end users have? Is the user fully literate? Health aspects such as dementia, ADD, deaf, colourblind, etc. should be noted in app design. 6. Does the country in which the app is being deployed have specific content, data, freedom of speech, etc. requirements? Are there specific features that would increase adoption in a specific country? 7. In what geographical context will the app be required to operate? Does this have an effect on the available network coverage? Will the network coverage affect the functioning of the app? 8. How will end users access the products, services or technologies? Are there any barriers hindering access?
Control	Operation	1. Reliability and performance 2. Data quality 3. App deployment 4. Support	1. Are the software and the corresponding infrastructure reliable? How can the performance of the app be measured? How does this reflect on the back-end platform? 2. Is the quality of data adequate for its desired purpose and possible further use? Specifically in health, structured or unstructured data may be required 3. Does the app require specific deployment activities? Specifically in enterprise apps, such as within mines, factories or hospitals, training may be required 4. Is there support readily available for the end users? Support can be in-app support or within the developer or platform owner firms
	Feedback	1. User data feedback 2. Quick updates	1. What feedback data can be obtained from the end user? Can this data be used to improve the app or the platform? Possibility of mining marketplace data, surveys, incorporate activity logs, controlled-environment experiments, etc. 2. Can updates be implemented rapidly? New versions may be required to run on specific operating systems
	Privacy and Security	1. Laws and regulations 2. Data privacy and security 3. Data governance	1. What are the possible laws and regulations related to the industry in which the app operates? 2. How will the privacy and security of the end users be ensured? 3. How will the end-user data be stored? Who within the ecosystem have access to what data? Will developers share data within the ecosystem?
Interface	Usability	1. Learnability 2. Understandability 3. User requirements	1. Can the app easily be learnt? Does it require dexterity? Can the app easily be used to its fullest extent without tremendous learning time? 2. Is the navigation through the app logical? Are there confusing elements such as buttons or layouts? 3. What are the specific needs and requirements of the end user to enable usability of the app?
	Design	1. Visual aspects 2. Level of exposure 3. Pricing 4. User comments 5. Other marketplace related factors	1. What will the app icon look like? What will the visual layout of the app interface entail? Will this be a selling-point of the app and encourage adoption? What is the envisaged user experience? How can the use of colours and fonts aid in the best possible user experience? 2. How popular is the app or the platform amongst the end-users? Has the app been successfully implemented in other countries, industries? Popularity has an effect on adoption 3. How does the end-user target-market influence the pricing of the app? Will the platform owner provide guidelines regarding app pricing? 4. Is there an option for end users to give feedback on the app? Specifically regarding crashes, speed, difficulty of use, unnecessary features, etc. 5. Should the app comply with specific marketplace requirements? Apple for example removing apps not built on 64-bit architecture

Evaluated and Adapted Framework:
Dimension Two: Platform Development Canvas

1 Platform core

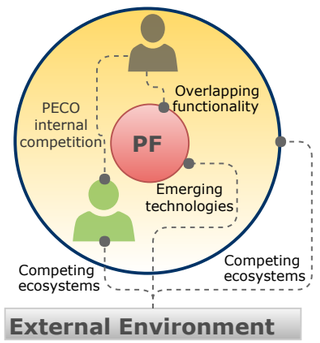


2 Ecosystem and Environment

Select and build ecosystem partners

Create personas
Link to value creation, capture and delivery for each ecosystem partner

Consider Ecosystem Dynamics



Regulations Standards Protocols

Regulatory Authorities

Disease Profiles

3 Platform and Governance Design

Define Value Creation Logic

Establish Platform offering → Consider ecosystem value contributors → Monetisation (Value capture and distribution)

Select Revenue Model
- Subscription
- Percentage profit
- Per user
- Per feature
- Based on project scope
- Performance based credits
- Outsourcing/sponsorship

Architecture Design Stacks

S.O.A Approach
Black boxes and APIs

Capability Stack
Platform Building blocks

EHRs and EMRs use

Data Silos

Integration Interoperabilty

Security and Privacy

4 Managing and Operation

Possible Control Mechanisms

Formal Control
Design rules and standards
Documentation
Penalties
Monitoring & evaluation
Content regulation
Review processes
Development aids

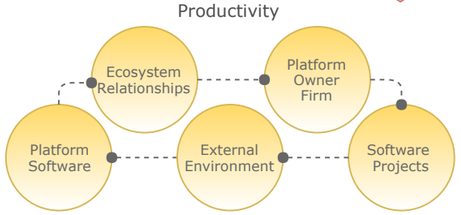
Informal Control
Common values
Shared beliefs
Community building
Methods of guiding behaviours

Openness Dimensions
Boundary resources
Governance
Research and development
Platform management
Marketing and sales
Consulting and support

End-user
Developer
Internal platform

Support Structure

Ecosystem Health Watch
Robustness
Niche Creation
Productivity



Health and Technology Education

Available Devices

Data availability and cost of data

5 Evolution

Platform Evolution and Maturity

Goals
Priorities

Evaluate success of balancing factors
- Modularity
- Openness
- Entry barriers

Evaluate boundary resources
- Securing
- Resourcing

Incorporate Feedback

Stumbling blocks

Feedback Messages

Screen External Environment

New laws, standards or protocols

Emerging technologies

Add additional ecosystem partners

Screen competing ecosystems and relevant industries

Software Ecosystems
Business Ecosystems

Information Systems
Software Engineering
Economics

Management
Economics
Ecosystem Governance

Innovation
Technology Management

Chapter 8: Framework evolution Part 4: Towards a final management tool

Chapter 8 key objectives:

- Introduce the case study phase of the evaluation process
- Give a background on how to conduct a case study
- Describe the case study process for Mezzanine Ware
- Analyse the case study data and present the findings
- Reflect on the application of the tool on Mezzanine Ware
- Reflect on the use of the tool in a developing country health context

8.1 Introduction

Chapter 8 comprises the concluding step in the evaluation of the framework. This evaluation stage includes an in-depth case study on a successful technology platform firm, Mezzanine Ware, which operates within the South African health context. An overview of the case study process will be given, followed by a background on Mezzanine Ware. The case study data analysis will be discussed and the subsequent recommendations, conclusions and modifications to the framework presented. The outcome of the case study was to gain insight into an existing technology platform firm, relate the data to the framework and adapt and modify the framework where needed. This adapted and modified framework resulted in the final framework and management tool. The context of this chapter is indicated in Figure 78. The context of this chapter within the evaluation process is shown in Figure 79, included on the next page.

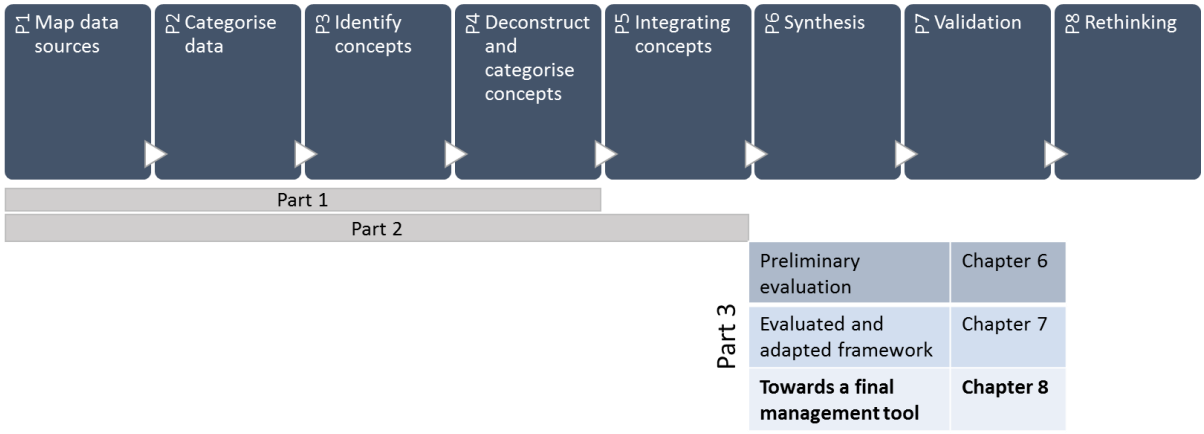


Figure 78: Document context diagram: Chapter 8

8.2 Case Study: Mezzanine Ware

Yin [70] recommends conducting a case study when an explanation or the 'why' or 'how' of a phenomenon is required. It is also particularly useful when an in-depth description of a situation is required. Therefore a case study can be defined as "*an empirical enquiry that investigates a contemporary phenomenon in depth and within its real life context*" [70, p. 18]. Subsequently, a case study was chosen as the best approach to gain in-depth understanding of how a successful technology platform operates, how it is managed and how this can relate to the framework. The aim of this case study is therefore to understand how Mezzanine Ware designed, developed and implemented their platform and firm, to relate this back to the framework and evaluate its usability and usefulness in this context.

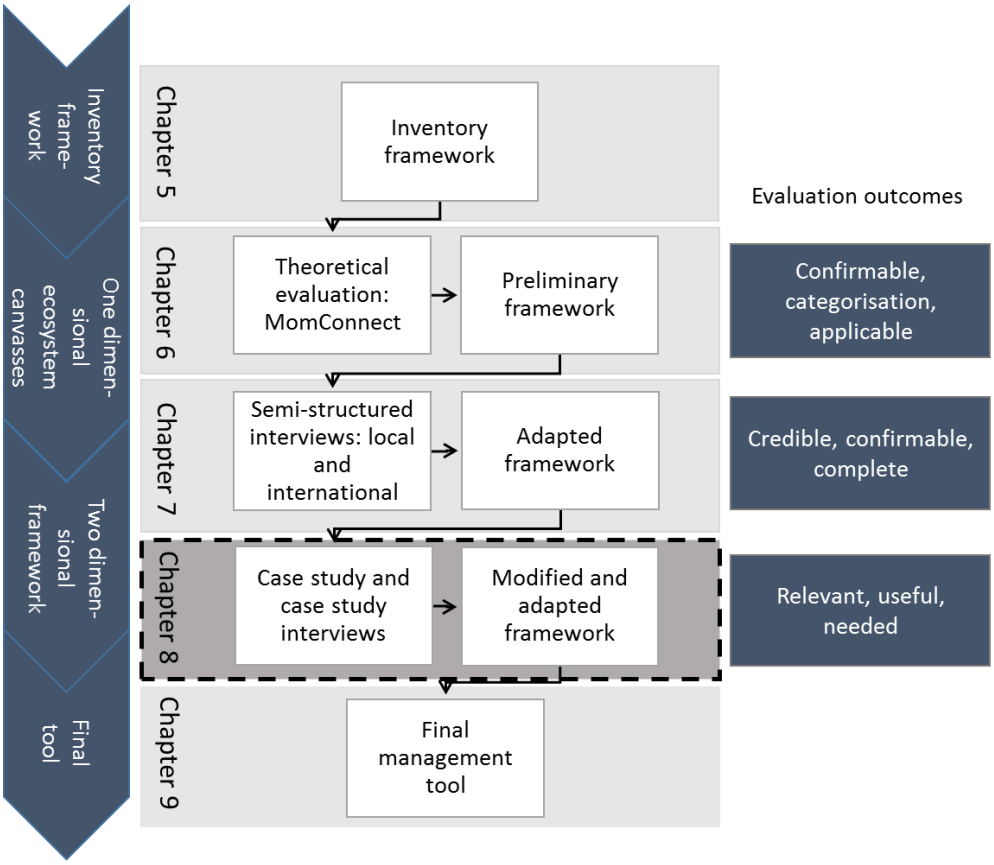


Figure 79: Overview of Chapter 8 context in the framework evolution and evaluation process

Yin [71] states that case studies can be exploratory, explanatory or descriptive. Exploratory case studies often precede social research, explanatory case studies are used during casual investigations and descriptive case studies follow the development of a descriptive theory. The case study conducted in this research is classified as an explanatory case study. A detailed process for conducting case studies proposed by Tellis [74], was followed. This four-step process is illustrated in Table 52.

Table 52: Four-step process for conducting a case study [74]

Case study step	Description	Section
1. Design the case study protocol	Determine the required skills Develop the protocol Review the protocol	Sections 8.2 and 8.3
2. Conduct the case study	Prepare data for collection Conduct interviews	Sections 8.2 and 8.3
3. Analyse the case study evidence	Develop analytic strategy	Section 8.4 – 8.7
4. Develop conclusions, recommendations and implications		Section 8.8

Yin [71] suggests that the interview protocol includes four elements. Firstly, it should include an overview of the case study and its context within the larger project. Secondly, the protocol should mention the field procedures which refer to the data sources and locations of those sources. Next, the case study questions are included and the protocol concludes with a guide on the case study report.

The approach taken by the researcher was to define the role and aim of the case study within the larger project as done earlier in this chapter. The case study was then segmented into three distinct components and the methods of data collection for each component identified. These components and procedures are shown in Figure 80. Subsequently, the researcher developed the questions that will guide the case study interviews and planned the outline of how the case study will be documented and presented. An important aspect of the case study was the ethical considerations. As stipulated by

the REC, the researcher obtained an institutional permission letter from Mezzanine Ware, as well as distributed consent letters before obtaining data from the interviewees.

Figure 80: Three case study components and their respective resources

The first component of the case study was the collection of background information on Mezzanine Ware. This was done though acquiring and reading online sources, news articles and documents. The second and third components both comprised interviews with employees. The interviews conducted as a part of this case study differed from those conducted in Section 7.2. The Section 7.2 interviews' aims were to evaluate the concepts included in the framework and identify missing elements. The approach taken for the case study interviews was to investigate and understand how Mezzanine Ware operates, how they are managed and subsequently relate this back to the framework. The interviews for this case study were semi-structured and the predetermined questions were derived from the framework. The interview process was similar to that of Section 7.2 and followed an adaptation of the process outlined by Rabionet [68]. The process followed is outlined and described in Table 53.

Table 53: Semi-structured interview process for case study interviews [68]

Stage	Stage description	Within this research
Select interview type	Choose between structured, semi-structured and unstructured interviews	Semi-structured
Establish ethical guidelines	Investigate possible consequences, consent, confidentiality and protection issues regarding the interview.	Ethical clearance from REC, refer to Section 1.8 and Appendix C.
Craft interview protocol	Gather information regarding context and develop questions and follow-up probes.	Section 8.3
Conduct interviews	Conduct and record the interviews.	Section 8.3
Analyse the interviews	Data analysis	Section 8.4 – 8.7
Report the findings	Presenting the results of the interview data	Section 8.8

As mentioned previously, the interview questions were derived from the framework. Therefore the interviews were conducted in two stages: (1) relating to the ecosystem dimension of the framework and (2) relating to the platform development dimension, as shown in Figure 81. The approach was to prompt the interviewee to discuss the overarching categories of each of these dimensions in order to gain an understanding of how Mezzanine Ware operates in each of the categories.

As suggested by Yin [70], care was taken to structure the questions to investigate the organisation and not the individual. By structuring the interviews using the framework as a guide, the transcription process was simplified, as the predetermined framework categories could be used. This also facilitated the data analysis and interpretation and resulted in missing categories being easily identifiable. The three case study components' data could be collected and subsequently transcribed, synthesised and analysed.

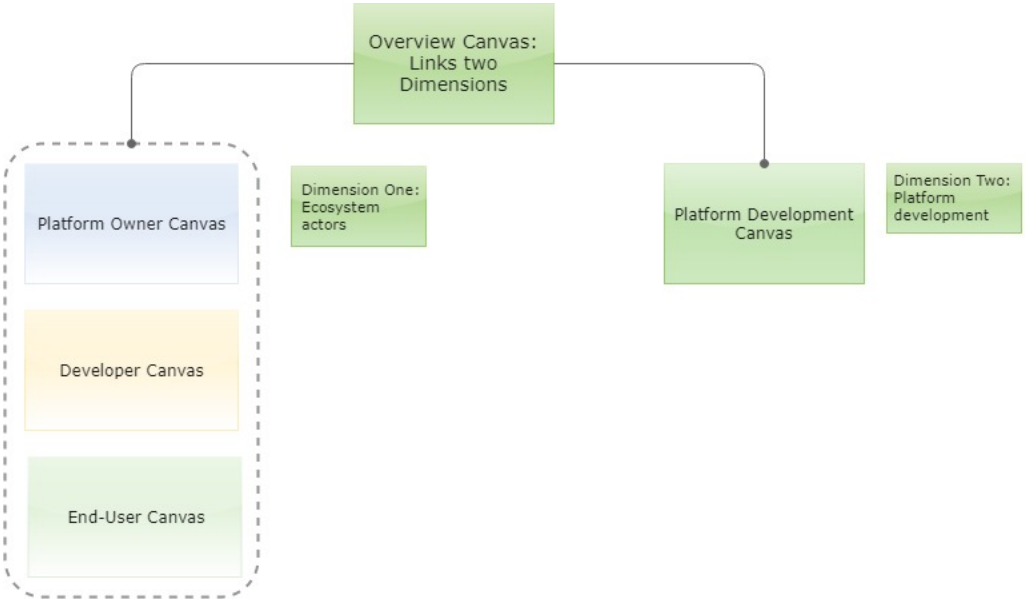


Figure 81: Case study interview structure derived from framework structure

8.3 Case study data collection

The data for the case study on Mezzanine Ware comprised different sources. The selected sources corresponded with each of the three case study components from Figure 80. In order to obtain background information on the firm and an overview of its platform, products and values, the researcher gathered data from the company website, online news articles, a GSMA publication and organisational notes that were made available to the researcher. The collective analysis of these sources added to the first two components of the case study, namely background information and insight into the firm as shown in Table 54.

Table 54: Three case study components and Mezzanine Ware data sources

Component	Method or application
1. Background information	Mezzanine Ware Website, news articles, GSMA publication, Organisational notes
2. Insight into the firm	Interviews and discussions with 5 diverse employees of Mezzanine Ware, Organisational notes
3. Usefulness of tool confirmation	Interviews with Mezzanine Ware employees

The researcher also conducted semi-structured interviews with five Mezzanine Ware employees to add to the second and third components of Table 54. The interviewees were selected based on their roles at Mezzanine Ware. The selection approach was to interview a diverse range of employees in order to get a more comprehensive picture of how the firm operates. The diversity of the five interviewees included a focus on product development, platform development, platform support, a developer's perspective, managerial overview, ecosystem and evolution.

The interview questions were formulated in order to investigate certain aspects of Mezzanine Ware and subsequently link the data back to the framework during the data analysis. The interviews themselves and subsequent data analysis followed a cyclical process as illustrated in Figure 82. The framework canvasses with incomplete detail were used to derive the structure for and thereby direct the semi-structured interviews. This included asking predetermined questions in order to gain an understanding of how Mezzanine Ware operates. During the data analysis of the interview data, these insights were related back to the framework. At this stage, the usefulness and applicability of the framework in the Mezzanine Ware context were determined. Component three of the case study (see

Table 54) was also incorporated into the interviews. This component was used to establish whether or not the framework would be useful to the firm.

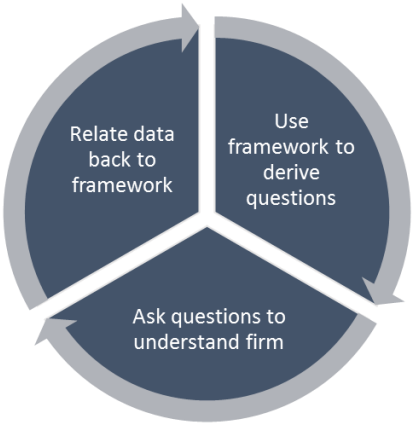


Figure 82: Cyclical case study approach

The interviews were conducted following six predetermined steps. The first step included giving an overview of the project and the aim of the case study interviews. This step was concluded by asking interviewees to complete the REC recommended consent form (see Appendix C). Step two of the interview process aimed at defining the interviewee's role at Mezzanine Ware. This information could then be used to emphasise and probe in specific areas during the interview. Thirdly, the handouts of the incomplete framework were given to interviewees with several areas purposefully left blank. The framework was concisely explained in order to ensure that the interviewee knew what is meant by each part of the framework. Following the framework explanation, the interviewees were asked regarding the dimension one and dimension two components of the framework specifically relating to Mezzanine Ware. This step focused specifically on the 'what' and 'how' of Mezzanine Ware for each aspect of the framework. The final step in the interview process comprised asking the interviewee for feedback particularly with regard to the usefulness of the framework.

Following the background information component, the methods of obtaining insight into the firm and confirming the usefulness of the tool, the data could be synthesised and analysed and linked back to the framework. These components resulted in a comprehensive overview of Mezzanine Ware as a firm as well as their technology platform. The in-depth firm operational and managerial details could not be obtained during the MomConnect theoretical case study and were therefore emphasised during this case study process.

8.4 Mezzanine Ware overview

Mezzanine Ware is a software-based firm that provides mobile solutions across Africa, specifically within the agriculture, education, health and utilities industries. Mezzanine embraces the digital health opportunities that many countries in Africa have not yet explored. The popularity of mobile devices in both urban and rural areas favourably positions digital technologies as possible solutions to health system challenges. Mezzanine's operational regions in Africa include South Africa, Kenya, Tanzania, Zambia, Mozambique and Nigeria. Their aims are to provide cost-effective and scalable software-based solutions in the form of Business to Business (B2B) or Business to Government (B2G) solutions. These solutions are predominantly developed using their software platform called Helium and they also use other shared managed services.

Mezzanine currently has a total of five tools across five African countries in the health industry. These tools include a Stock Visibility Solution (SVS), mVacciNation, AitaHealth, LEAP and eLABS. SVS is a stock visibility solution that is used in healthcare facilities to record stock levels and thereby reduce the number of stock-outs. mVacciNation is a mobile solution that tracks vaccination schedules for children.

AitaHealth is a smartphone application that collects key data on health indicators and aids in decision support in healthcare facilities. LEAP is a learning application that is used to train clinical health workers. eLABS is also a mobile application that can track and send blood sample results electronically. The SVS, a B2G solution, and AitaHealth tools are currently operating in South Africa.

Mezzanine's approach is to move away from developing typical siloed technology solutions to developing solutions via a shared service model. This shared services model is shown in Figure 83 (a clearer image could not be obtained as the image was supplied by Mezzanine Ware). Such a model has numerous financial and performance-related benefits. These benefits are enabled by the shared technology as well as the shared managed services across the different client bases and countries. The shared service model allows for rapid first prototype deployment and the platform owner has fewer software solutions to exclusively support and maintain. The Mezzanine Helium technology platform enables this approach by hosting multiple solutions simultaneously.

Figure 83: Mezzanine Ware Helium platform multi-tenancy illustration

There are five core capabilities that a client solution at Mezzanine Ware can entail. These capabilities include: (1) mobile devices, (2) an application, (3) an application server and hosting environment, (4) a web-based management portal (PC version) and (5) a system administration and web management portal. The core capabilities are described and their benefits presented in Table 55.

Table 55: Mezzanine Ware five core capabilities, their descriptions and benefits

Core capability	Description	Benefits
Mobile devices	Equipment with a Helium-enabled mobile device. This capability includes device and individual registration as well as device and application setup.	○ Centralised registration ○ Authentication and authorisation system
Application	Android application which is easy to use.	○ Store-and-forward ○ Speed and convenience or reporting ○ Data quality control ○ Location based services ○ Data encryption
Application server and hosting environment	99% availability Service Level Agreement requires a Tier III data facility such as the Vodacom facility. Such a facility comes with the infrastructure and support services. It also follows international standards in terms of security, reliability and maintenance.	○ Bandwidth ○ Data security ○ Stability ○ Skilled support ○ Internet hosting environment
Web-based management portal	Access to a web-based management portal from any location at any time.	○ Facilitates low bandwidth communication ○ Decision-support services ○ Notification services

Core capability	Description	Benefits
		○ Data warehouse and reporting tools
System administration and web management portal	Useful capability to deal with several administration aspects. This is particularly useful to programme managers.	○ Centralised management ○ Handset traceability ○ Logging of all transactions

8.5 Platform profile

In connection with the Pre-use Canvas of the framework, the platform profile could be determined for Mezzanine Ware. The platform profile considerations are shown in Figure 84. Mezzanine can be classified as both a transactional and innovation platform. It comprises its foundational innovation platform on top of which several transactional platforms are built. Therefore the platform type is classified as an integrated platform. Mezzanine also operates as both an internal and external platform. However, the number of external developers is currently very small. In terms of distribution channels, Mezzanine provides web-based and mobile applications. Their application industries include agriculture, healthcare, education and utilities. Due to the integrated nature of their platform, the platform profile could essentially also established for each of their transaction platform solutions in each of the different industries.

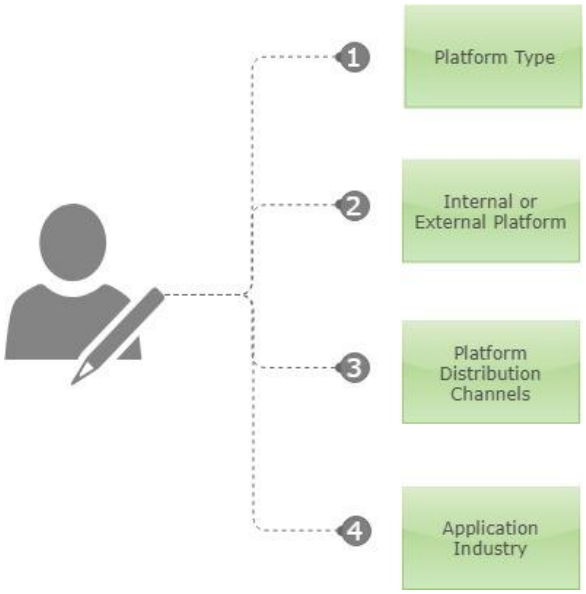


Figure 84: Establishing Mezzanine Ware's platform profile

The Stock Visibility Solution (SVS) can be used as an example of how the profile could be established for one of Mezzanine's solutions. The platform type would then be a transactional platform, linking the NDoH with healthcare workers and facilities. In this case the applications are developed internally by Mezzanine's own developers. The SVS is accessed via both an online web-based portal and through its mobile smartphone application. The application industry of the SVS is healthcare in Africa. Following the better understanding of the profile of Mezzanine Ware, the investigation into the firm and its operations could commence and be linked back to the framework in terms of its two dimensions.

8.6 Ecosystem actor understanding and design

The Mezzanine Ware platform ecosystem is embedded within other ecosystems as shown in Figure 85. An inside-out approach will be followed to describe these embedded ecosystems. Mezzanine Ware has to build an ecosystem for each of their products and services. With the SVS, they partnered with the National Department of Health as well as clinic workers. Both of these actors form a part of the SVS ecosystem, but are most likely not a part of any of their other product or service ecosystems.

Moving to the next embedded ecosystem, there is the platform ecosystem as initially described in this research. This platform ecosystem includes: (1) platform owner, (2) developers and (3) end users. Not all of the developers and end users are related to each product or service that Mezzanine deploys and its corresponding product ecosystem. The final ecosystem is the comprehensive Mezzanine ecosystem. This includes stakeholders such as Vodacom, who are directly or indirectly a part of every project and ecosystem that Mezzanine participates in. Therefore, the framework will be adapted to include the possibility of other ecosystems that the platform owner firm and its end products, services and technologies may form a part of.

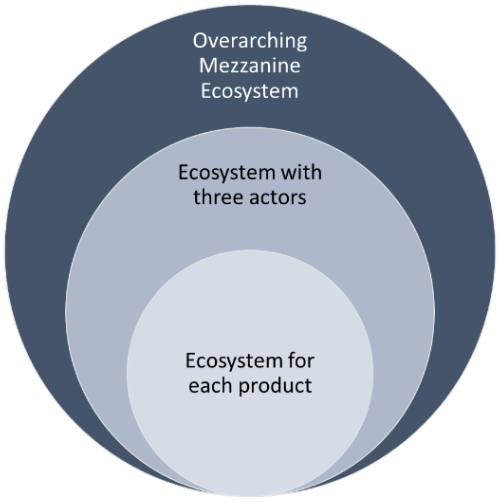


Figure 85: Mezzanine Ware's embedded ecosystems

The Mezzanine Ware platform ecosystem and its actors were investigated next, as these are the focus of the framework. The actors included the platform owner firm, the developers and the end users. The investigation was led by, but not restricted to, the framework's ecosystem canvasses. This formed the first part of the interviews. The investigation of the online documents and other resources was also guided by, but not limited to, the framework concepts. It should however be noted, as indicated by the Overview Canvas, that the ecosystem and platform development dimension concepts do overlap in certain ways. In other words they are not mutually exclusive. The discussion draws from the case study data and highlights elements that were significant in Mezzanine's success. The discussion relates to the framework where applicable. Aspects that were key in the platform development process are discussed in Section 8.7.

8.6.1 Platform owner

The platform owner canvas comprises five categories namely platform design, platform ecosystem design, platform owner design and evolution. Mezzanine was investigated in terms of how they operate in each of these categories.

Mezzanine's purpose is to create productive societies which refers to a "*healthy, well-educated society with an economic active adult population".* Mezzanine operates on four fundamental values: (1) trust, (2) accountability, (3) mastery and (4) being nimble. They aim to provide enterprise-ready applications by providing a complete managed service. Rapid deployment of the Minimum Viable Product (MVP) is facilitated by Helium and is therefore also one of Mezzanine's competitive advantages. Currently, they have 15 products across all of their industries, where each project is approached as a business on its own. The technology used in these projects is all the same, but their business approaches differ. In general, Mezzanine operates based on two models when delivering their services, namely a product or project model. A product model entails that Mezzanine takes all the risk in the project. They make the initial investments and commit to developing, selling and growing the service. In a project model

the client takes all the risk. The client drives the project and requires specific functionalities from Mezzanine.

Helium is the software platform and driving force behind the Mezzanine Ware solutions. Helium adopts a service-oriented design in that it can facilitate a variety of services such as identity management, data storage, database merging and sending and receiving payments. Mezzanine's platform can provide twelve capabilities including mobile money, workflow and decision support, feature phone, smartphone applications, cloud hosting, security, monitoring, content management, Internet of Things, support, web services and analytics. They recently became ISO 27000 certified, which indicates that they are a serious player in the software development landscape. These sets of ISO standards help in keeping information assets secure.

Two specific uses of the Helium platform include the development of web applications and middleware. The web applications are designed on the Helium platform and supported by the Helium back end. Mobile applications used in Mezzanine's solutions are developed using a third party called Journey Apps. The mobile apps are developed on the Journey Apps platform and support provided by Journey Apps teams. Helium therefore also acts as the middleware between the Journey Apps mobile app and the web application. The use of the middleware functionality can be illustrated with an example on survey data, as illustrated in Figure 86. Field workers can complete a survey on their mobile application and thereby generate certain survey data. This data is then uploaded to Journey App's back-end where it is requested by Helium middleware and pulled into the Helium back end. A web application user can then view this survey data.

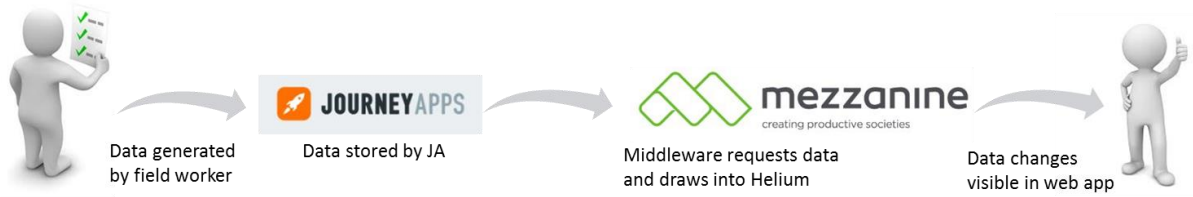


Figure 86: Example of Mobile application to Web application data flow

The ecosystems in which Mezzanine operates are diverse and not limited to only the platform ecosystem (platform owner, developer and end user) as defined in this research. They operate in various industries and in numerous countries, therefore the subsequent ecosystems vary. As mentioned previously, Mezzanine is a subsidiary of Vodacom. Therefore Vodacom forms a crucial part of Mezzanine's diverse ecosystems. Other stakeholders that often form a part of their ecosystems are local governments and NGOs. In Zambia for example, their clients are WFP and UNICEF, but the end users of the applications are within the Government. This separation of clients and end users is a general model for their projects as the end users can often not finance the initiative or may not know how to address their own problems. In terms of monitoring their external environment, Mezzanine employees are encouraged to remain up to date with emerging technologies and employees often attend talks and workshops.

Mezzanine's firm, like their platform, comprises modular components. They have a core platform development team, a DevOps team, product developer teams, a support desk and an admin team. These teams each have their own role and responsibilities within the firm. The core platform development team is responsible for the maintenance and evolution of the Helium platform. This team has three work streams: (1) fixing software bugs, (2) working on improving the platform and (3) implementing the client's feedback. The DevOps team provide the monitoring and support for developers and the platform. The product developer teams include the developers and are responsible for the successful design and implementation of a new product or service. The support desk provides the first line of support for clients.

Feedback and support form a major part of Mezzanine and their platform's success. They follow a scrum agile process in their platform strategy. Different forms of feedback are therefore used in the iterative development process. The first form of feedback is from the clients and end users. This feedback would be registered via a ticketing process that contains possible product and platform improvements. These tickets are then discussed by product teams and prioritised. The highest priority feedback elements will then be implemented by the core platform team. There is also a platform forum where developers can express their feedback regarding developing on the platform.

8.6.2 Developers

The following section of the case study focused on the developers of the platform. The main categories that were purposefully investigated were potential entry barriers, ecosystem and technology considerations, control and support. Mezzanine has both external and internal developers. However, their external developer ecosystem is very small.

Even though the majority of their developers are internal to the firm, there are certain entry barriers that are associated with the platform. Probably the most prominent entry barrier that was observed is the custom and unique development language required to develop on the Helium platform. The Helium development language is unique and is not used anywhere else in the world. This has been a major concern for Mezzanine when considering building their developer ecosystem and opening up their platform for external developers. Subsequently, the core development team is currently working on a new version of the platform that will operate in a common software development language called JavaScript. Another entry barrier that Mezzanine has discovered is that developers cannot customise their apps. The look and feel of the apps are predetermined and consistent throughout all applications.

Mezzanine has however worked hard in lowering other developer entry barriers. As a result of the unique development language, there are vast amounts of support available. Mezzanine has developed an extensive Helium tutorial that all new developers need to complete. It is also facilitated by a Helium proficiency test that developers regularly have to write to ensure that they are up to date with the platform and its functionality. Therefore, the platform and its functionality are well documented and available for referencing. The Helium platform also focuses on developer usability and aims to make development simple. The goal is to enable someone with limited digital literacy to be able to develop using the platform. Developers also do not need to have any user interface (UI) design experience as this is mostly predetermined by the platform. In order to develop on the platform, any basic PC or laptop computer would suffice as strong computing power or complexity are not required. Development can also take place on Linux, iOS or any basic type of operating system. This aligns with their strategy to focus on enabling development specifically in Africa where the latest MacBook, computing power or technology might not be available. The external developer pricing approach is to request an end-user licence fee. Therefore the developers do not pay in order to develop; they only incur costs once their business is growing.

The developers are also considered in the ecosystem and technology infrastructure of the platform. In order to co-evolve with the developers, encourage innovation and reduce possible tensions, the developers have an influence on what should change on the platform. This also relates back to designing the platform to focus on usability not only for end users, but also for the developers using the platform. Feedback therefore forms a crucial part of a developer's role and their opinions are reflected in the platform software's version updates. The technology infrastructure also has several monitoring and evaluation mechanisms. In the case of inefficient or bad developer coding, the platform is able to monitor and identify these. Software executions are timed and successful and unsuccessful executions are monitored. In the case of a software loop being out of control and potentially harming the platform, the platform forces the software loop to terminate after five minutes of execution time. This illustrates the built-in feedback and security measures.

Mezzanine also implements control mechanisms and provides support for developers. Developers are asked to sign NDAs as they often have access to sensitive data. They are also informed as to what they can and cannot do with this data. As mentioned, the platform makes developer activity traceable and visible. The platform also allows for each app developed to run in its own sandbox. Therefore, the apps do not have access to any other apps running on the platform. The project owners also implement a control mechanism by requiring the developers to report on their progress daily. Support for both internal and external developers is provided mainly through the DevOps team. If the external developer ecosystem grows in future then Mezzanine plans to provide a dedicated external DevOps team. The developers are therefore equipped to develop products, services and technologies.

8.6.3 End users

The final ecosystem element focuses on the end users of the applications developed using the platform. The main categories in this section include context of use, control from the platform's side and the interfaces. The most important realisation during the investigation of Mezzanine with regard to end users was that in Africa, the end users would typically comprise two groups: (1) the client (such as UNICEF) and (2) the end users (governments). The reason for this is that the end users of the product, service or technology developed on the platform often cannot afford the project or are unaware of the possible improvements that the technology could provide. Subsequently, an intermediary or client is needed.

Mezzanine designs each product specifically for the target end user. Therefore, context of use is a key consideration for both back-end and front-end development. The Mezzanine team spends time with the end users to understand them, their context of use, the business process behind the application and how this affects the design process. The user interface design is common throughout all Mezzanine products, focuses on being simplistic and follows the same logic as all other Mezzanine applications. Therefore, if the end user can use one of Mezzanine's apps, they would be able to use all of their products. The skill comes in developing the dashboards to specifically meet the monitoring and reporting requirements of diverse users, while maintaining the app commonality. This refers to specific requirements of different facilities, districts or provinces. By tailoring these dashboards, increased adoption of the solutions has been observed.

Another challenge that Mezzanine had to design around is the ability to support offline functionality in their solutions. This is particularly significant in areas where there is poor connectivity. Limited connectivity resulted in the use of services including short message service SMS and USSD.

Certain control from the platform's side also forms a part of the Mezzanine approach. Mezzanine tracks predetermined KPIs, such as frequency of use in each of the facilities, as a part of their SVS product. User feedback is also crucial. Regular client forums are used to highlight the needs of the clients and end users. Mezzanine ensures proper training of all its end users in order to address the reality of low technical literacy and to facilitate the adoption process. Therefore, it was observed that Mezzanine's strategy includes the consideration of all ecosystem actors. The subsequent focus of the case study was on the platform development canvas and on how this is translated within the Mezzanine context.

8.7 Platform development parts

Subsequent to the ecosystem investigation, the platform development parts were investigated. Again, this was done through employee interviews, online resources and other elements shown in Table 54. The investigation was guided by the Platform Development Canvas. The researcher was however not bound by this structure. The Platform Development Canvas comprises approaches or interpretations of the Ecosystem Canvas categories and concepts. The Platform Development Canvas emphasises possible approaches to answer the 'how' of each development stage. Please note that several data

points related to the platform development parts were deliberately included in Sections 8.6.1 to 8.6.3 in the ecosystem actor discussions. The reason for this is that the dimensions are closely related and several data points overlap. The researcher found it to better facilitate the flow of the document to include some aspects in the previous sections.

8.7.1 Platform core

Mezzanine is clear on what their core purpose is and identified the 'why' of their platform. They have a mission statement that drives their teams to create productive societies in Africa. They focus on four specific industries and direct their platform efforts accordingly. Mezzanine adopts an agile business approach and relies heavily on feedback from all ecosystem participants. Mezzanine functions according to a large degree of non-linearity in order to respond to rapidly changing client and user needs. However, they rely on their core strategy to direct them on this road of non-linearity.

8.7.2 Ecosystem and environment

Mezzanine actively builds its ecosystem and defines the roles and responsibilities of each ecosystem partner. Key factors in the success of Mezzanine and their ability to scale are that they are a subsidiary of Vodacom and that they have many public-private partnerships (PPPs). The agreement with Vodacom allows Mezzanine to leverage their network coverage, but still operate independently. This permits them to take greater risks and be more agile. Mezzanine and Vodacom both benefit from this partnership (value for each stakeholder). Vodacom benefits in the form of expanding into more difficult to reach markets. Another key success factor is the cooperation of trusted partners who can oversee the required change management at the healthcare facilities, specifically referring to integrating with the current digital health tools at these facilities. The final actor that forms a key part in Mezzanine digital health ecosystem is that of local governments. The chances of the solution overcoming the pilot phase is significantly greater with government buy-in. As an example within the SA health context, the SVS ecosystem and their clearly identified roles are indicated in Figure 87.

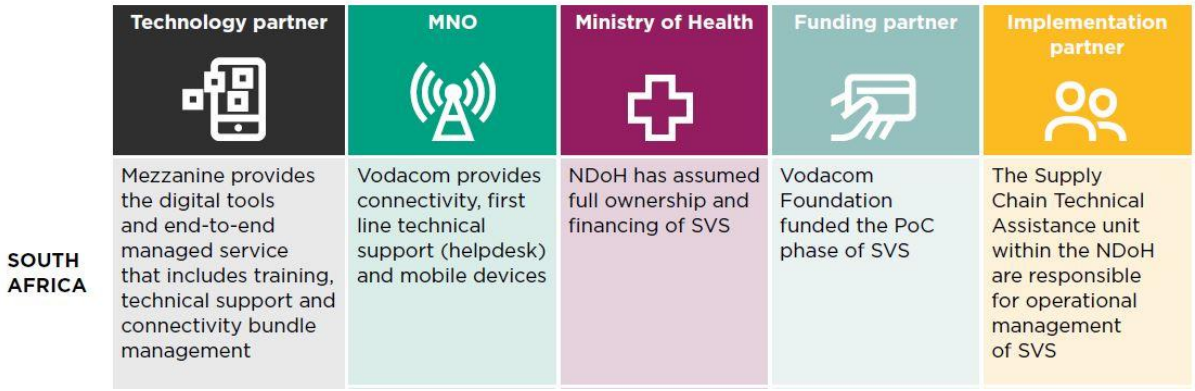


Figure 87: Mezzanine Ware's Public-Private Partnerships model

8.7.3 Platform governance and design

The platform governance and design part of Mezzanine can be divided into two sections: (1) value creation related and (2) technology infrastructure-related considerations. Mezzanine has a total of 15 different product offerings, each of which functions as a business on its own. Therefore, determining the value creation logic is key. Mezzanine clearly defines what the platform and firm can and cannot do. It leverages the platform capabilities and evolves the platform in line with its platform strategy. Relating to the ecosystem and environment part defined in Section 7.7.2, the contributions and potential value of each ecosystem partner are clearly defined and subsequently pursued. However, Mezzanine has a challenge to capture the value created within some of its ecosystem.

Mezzanine does not have a fixed monetisation strategy, and adapts their strategy for each new product. In a certain project, Mezzanine aligned the revenue model with that of the Ministry of Health (MoH) by considering their budget allocation and subsequently developed the pricing strategy. Donor funding also plays a large role in the success of Mezzanines products. Donor funding often provides the financial support for the project up to product maturity. It can therefore be concluded that monetisation is a challenging aspect, particularly in the African context. The second section for consideration relates to the technology infrastructure. Mezzanine uses the Service Oriented Approach sections of its platform and the platform provides certain functionalities that can be reused for each new product.

8.7.4 Managing and operation

The managing and operation of the Mezzanine platform and ecosystem has a large focus on the end users as well as control and support mechanisms. Both the support and control mechanisms have been discussed in Section 8.6.2. How Mezzanine adapts their offering to facilitate adoption within the end-user's context of use was mentioned in Section 8.6.3. Therefore, the managing and operation part of the platform development has previously been discussed.

8.7.5 Evolution

Mezzanine is actively pursuing the expansion of their current product, service and technology portfolios through four specific methods. Firstly, they are focused on are scaling their tools to a national level and secondly, entering new markets with their current tools. The third area of expansion includes growing their current value propositions. This refers to an increased amount of solutions that can address crucial health system challenges. The final growth initiative is to integrate with other health system initiatives, for example the NHI in the South African context.

Mezzanine's Helium platform has evolved over time as illustrated in Figure 88. Mezzanine initially created custom, siloed applications for each product that a client required. This led to high development costs as all app functionality had to be developed from scratch for each product. However, Mezzanine saw the potential of combining common functionalities within the apps and integrating them into a platform. This platform could be reused for all the products and the common functionalities did not have to be developed anew for each product. The product-specific functionalities could therefore simply be added to the platform, depending on client specifications. This significantly reduced the time and cost of development. Subsequently, Mezzanine can pursue their vision of providing affordable and rapid deployment of applications to clients as a result of their platform setup.

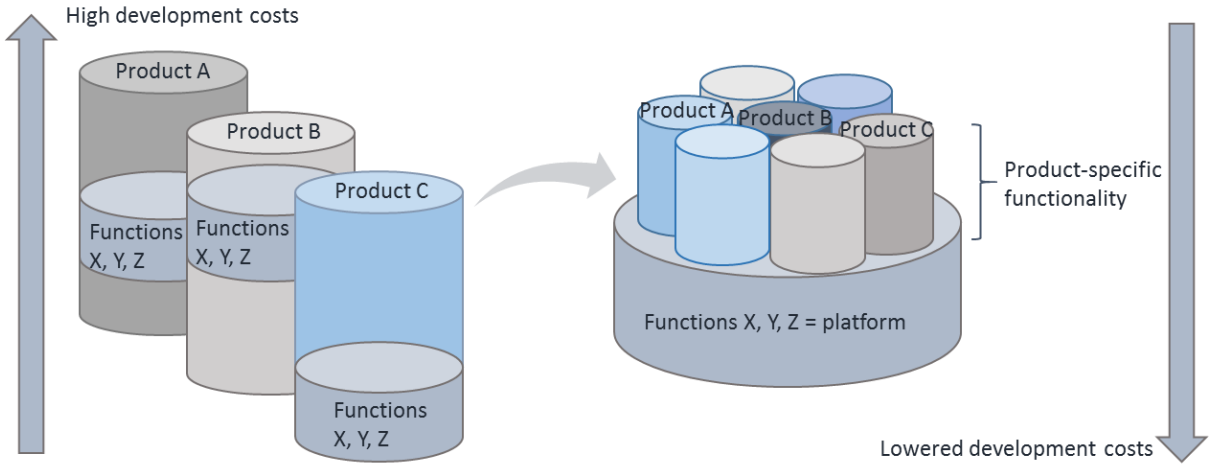


Figure 88: Illustration of Mezzanine Ware's platform evolution

The case study on Mezzanine Ware can be summarised in the Overview Canvas of the framework. This is however a concise summary and does not cover all the data from the case study. The Overview Canvas for the Mezzanine Ware case is included on the next page. This canvas also illustrates the use of the Overview Canvas. Mezzanine's Stock Visibility Solution was investigated in more detail as it focused specifically on the South African health context.

8.7.6 A closer look at the Mezzanine SVS solution

As a result of the interview data, the researcher realised that the Platform Development Canvas could be used in the development of solutions on top of the Helium platform. Mezzanine's SVS can be observed using the Platform Development Canvas. The SVS platform be viewed as a transactional platform (SVS) built on an innovation platform (Helium). The Platform Development Canvas for the case of Mezzanine Ware, included after Mezzanine Ware's Overview Canvas, relates the SVS to the platform development parts within the actual framework. This example also illustrates how the concepts from the dimension one canvasses can be related to the Platform Development Canvas.

The success of the SVS mobile health solution can be attributed to four factors: (1) its PPP model, (2) its client-centred approach, (3) its user-centred approach and (4) its partnership with the government. These factors influence the adoption, sustainability and scalability of the platform. The Platform Development Canvas can therefore also be used for each new service or product in the form of application(s) that is/are built using the Helium platform. The Platform Development Canvas provides a useful, logical, thought-provoking outline to facilitate the design, development, implementation and evolution of the complementary product, service or technology.

Following the investigation of Mezzanine Ware in terms of the dimension one and two canvasses, the recommendations, conclusions and modifications could be discussed and implemented in the framework.

8.8 Recommendations, conclusions and modifications to framework

The case study section concludes with additional concepts and modifications based on recommendations and conclusions from the data. The usefulness of the tool and recommendations to Mezzanine Ware as a technology platform firm are also discussed. The final discussion of this section elaborates on insights regarding a technology platform in the South African Health context.

Following the case study and its data analysis, the researcher identified additional concepts to be added and modifications to be made to the framework. Each additional concept or modification was considered for its contribution to the final framework by considering if it would be limited to the case of Mezzanine Ware. As a result, some apparently useful concepts or modifications applicable to the Mezzanine context were not added to the framework. Similar to the semi-structured interview data, there were structural and conceptual modifications. The context of the third and final stage of the evaluation process (E3) are indicated in Figure 89. It can also be seen that both conceptual and structural modifications were made to the two-dimensional framework.

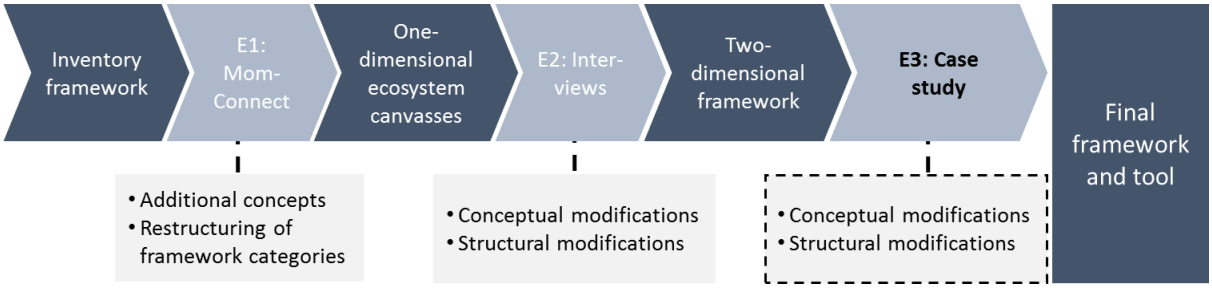


Figure 89: Context of framework modification and evolution: E3

Two-dimensional Overview Canvas: Mezzanine Ware

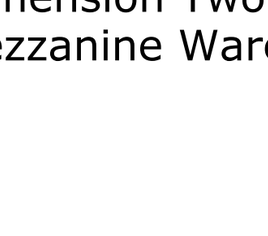
	Platform owner When I think of my own firm and platform	Developer When I think of the users of my platform	End user When I think of the users of end products/ services or technologies developed using my platform
1 Platform core What am I designing? Why am I designing it? 	• Aims to create productive societies in Africa • Nonlinear trajectory, directed by strategy • Currently 15 core products from which most new products are built	• Compliance to international standards • Actively builds trust in ecosystem • Fair value distribution approach	
2 Ecosystem and Environment Who is involved? Where is it implemented? 	• Dedicated staff responsible to stay updated with external trends • Encourages staff to stay updated with market trends • Niche market without major competitors Identifies key actors for each project • and industry Clearly defines roles and responsibilities • in ecosystem	• Develops platform for developer-ease-of use • Updates documentation to enable co-evolution • Does not have an active external developer ecosystem, therefore not all framework concepts are relevant	• Engages with the end-user environment and stakeholders prior to design of products • Identifies additional stakeholders for each product
3 Platform and Governance Design How will the platform be realised? 	• Procedures in place to scale business and platform • Provides developer toolkit for platform use • Platform not completely open • Offline and online app-usage enabled • Mobile and web applications possible • Diverse feedback methods implemented • ISO 27000 certified	• Ensures compatibility with developer and end-user hardware devices • Incorporates control mechanisms into platform to protect from bad developer coding • Developer feedback enabled and encouraged	• Physical, social, geographical and organisational contexts considered in platform and design of product/service • Country differences acknowledged and integrated in design • Accessibility of end users considered • Platform applications are by default easy to use and simplistic in design
4 Managing and Operation How will the platform be managed and operated? 	• Key processes within firm identified • Invests into firm culture • Clear vision shared by employees • Internal support from DevOps team • Gains trust within ecosystem to build reputation	• Developers informed regarding end-user data privacy and signing of NDAs • External developers in charge of own data • Mezzanine provides storage and backup • Tutorials and tests to enforce desired standards, as well as to provide support • Daily monitoring of developer progress on projects • DevOps team provides internal and external developer support	• App deployment facilitated • Training provided • Long-term support provided • User feedback enabled • Quick-updates possible due to nature of platform • PoPI considered in SA • Procedures to ensure usability of application
5 Evolution How should the platform and ecosystem evolve? What should evolve? 	• Constantly evolves platform based on new functionalities • Stays up to date with international standards • Works towards technology and business sustainability • Mature firm	• Developers part of platform evolution via ticketing system • Developers required to take Helium test regularly to ensure co-evolution • External developers compensated in the case of envelopment	• User and client feedback encouraged by product owners • User feedback ranked based on importance • Several versions of application implemented to ensure complete satisfaction and avenues for future work

Dimension Two: Platform Development Canvas: Mezzanine Ware

Explore if SVS would be useful

Determine vision

1 Platform core



2 Ecosystem and Environment

Vodacom provided seed funding for pilot

Establish the client and users for SVS: licenced to the government, a B2G tool, paid by the NDoH, used in clinics

Identify a product champion that buys into the vision

Mezzanine has access to the end-users of the product/service in order to witness how it will be used in current context

Identify different end-user managerial levels involved in product use. Relate this to different app usage options

Attend client meetings to clearly understand the problem to be solved

3 Platform and Governance Design

Determine whether the client's idea is technically possible

Workshop to establish the data model. Determine if data format(s) achievable as required by the client

Have the client draw up an Excel sheet of desired data and its layout. Use this in app back end design

Development according to lowest hanging fruit concept

One-time fee for hardware devices

Training fee(s) during deployment

Additional costs: additional training and change management

Design and deploy mobile and web applications

Mobile and web application data hosted in Vodacom data centre

Follow Software as a Service model. Establish service level agreement

SVS is designed to be easily replicated and implemented across country borders

Integration with NDoH systems, integration with healthcare facilities' systems. NDoH owns app data

Mobile interface is designed to be simple, straight-forward, easy to use

4 Managing and Operation

Dedicated team that leads the deployment. Deployment entails downloading, installing and setting up the apps on devices

Dedicated team for change management

Mezzanine follows up to ensure app is used correctly and correct outputs (as required by client) are obtained

Weekly logging reports

Phased support: during month one, there is constant support for product champions. This is steadily reduced until the app usage stability is assessed after three months and subsequently evaluated

Technical support (fix bugs and log complaints)

Train-the-trainers model

Operate with zero-rated data channels: app can be used even if zero balance on hardware SIM card

5 Evolution

The SVS undergoes regular iterations, including the addition of new features inspired by feedback

Product forum feedback (amongst developers)

Bi-weekly meetings to discuss new or changes to existing features

Regular platform updates, based on feedback from developers and end users

Software Ecosystems Business Ecosystems	Information Systems Software Engineering Economics	Management Economics Ecosystem Governance	Innovation Technology Management

8.8.1 Structural modifications to framework

The structural modifications predominantly occurred within the ecosystem dimension of the framework. On the Platform Owner Canvas, the case study data motivated for support to be segmented into platform support and platform owner firm support. It was also found that the vision category on the platform owner level should rather be divided between the platform design and platform owner firm categories. The current vision category comprised elements that should be considered in both of those categories. The platform owner firm category would also fit better when placed ahead of the ecosystem design category. Subsequently, the general order of the canvas categories would be more logical as the platform firm would then flow into the platform which in turn flows into the larger ecosystem and the subsequent evolution of all components. A summary of the modifications is indicated in Table 56.

Table 56: Case Study: Structural modifications to the framework

Dimension	Component	Structural modifications
Ecosystem	Platform owner	AD1. Split platform support and platform firm support AD2. Split vision between platform design and platform owner firm design AD3. Move platform owner firm design ahead of ecosystem design
	End user	AD4. Split end user into client and end user AD5. Split end users into hierarchical levels (such as government and healthcare workers) AD6. Rename control category to operation AD7. Rename operation category to deployment
Platform development	Evolution	AD8. Feedback going to each column, not just platform core

Another set of structural modifications took place on the dimension one End-user Canvas. The case study data provided insights into the funding and end-user contexts of a technology platform in Sub Saharan Africa. Within the South African public health context for example, the end users typically would not be able to pay for the applications themselves and would therefore need an external source of funding. They would most likely also not be aware of the benefits and solutions that the use of a platform could provide. The end users within this context would therefore comprise not only the end users of the applications, but also the client that is initiating or paying for the initiative. Specifically at Mezzanine, this categorisation of end users would comprise a client (for example UNICEF) and the end users (for example healthcare workers in clinics). Both these end-user components would need to be considered within the process of design, development and implementation of the platform and its subsequent applications. As a result, the framework End-user Canvas was adapted to incorporate both of these end-user parties, as shown in Figure 90.

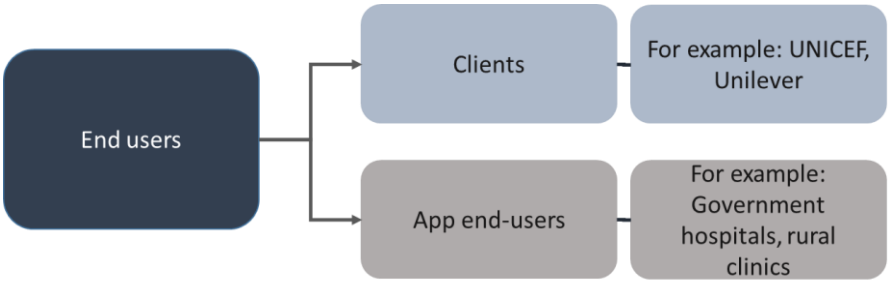


Figure 90: Splitting end-users into two components

The application end users had to be segmented further. This referred to examining the end-user context for possible hierarchical levels. For example, the application might be used by different managerial levels within the clinic or organisation where each level may have their own user requirements. Subsequently, this would have an effect on the design of the application. Therefore the

end-user managerial levels were also added to the canvas. The other structural modifications included renaming the 'control' category to 'operation' and adding a subcategory for deployment activities.

The only structural modification that was implemented in the Platform Development Canvas was regarding the evolution. The feedback loop from the evolution stage initially looped back only to the platform core part. However, each stage of the platform development process can evolve as a result of diverse sources of feedback. Therefore the feedback loop should feed into each of the platform development parts.

8.8.2 Conceptual modifications to the framework

The conceptual modifications are indicated and described in Table 57. Five of the conceptual modifications will be discussed in more detail: (1) Agile software development methodology (AD22), (2) technology stack (AD23), (3) standards (AD25), (4) transactional platform issues (AD29) and (5) evolution of components (AD32).

Table 57: Case Study: Conceptual modifications to the framework

Dimension	Component	Conceptual modifications	Description
Ecosystem	Platform owner	AD1. Stakeholder expectation management	Each of the stakeholders should be aware of the goals and vision of the platform. Also with regards to monetary aspects.
		AD2. Technology infrastructure hardware	The technology infrastructure category should include the hardware requirements such as servers, hard drives, etc.
	Developer	AD3. Design for developers in developing countries	Developers in developing countries may have older laptops, limited resources, below standard literacy, inability to back-up code themselves.
	End user	AD4. End-user adoption	Development may not always result in sustained user adoption. Therefore focus on ways of facilitating adoption.
		AD5. Change management for end users	How can the effect of the change in operations be reduced? Referring to the effect on job responsibilities and work protocols with new application.
		AD6. Communication	With the end-user canvas now comprising more than one group, communication between them and with the platform owner is key.
		AD7. Set-up or additional infrastructure costs	Referring to additional infrastructure required in the end-user context, or costs of setting up the technology.
		AD8. Trust from client and end users	Trust is not only key for developers, but also from end-user components. Especially if platform wants to scale in that industry.
		AD9. Product champion	Identification of an end user that shares in the vision and can direct the implementation on the end-user side.
Platform development	Ecosystem and environment	AD10. Adoption facilitating mechanisms for each end-user level	The end-user components can be segmented and techniques for increased adoption for each identified. (links with AD12)
		AD11. Different ecosystems to consider	Ecosystem with stakeholders, ecosystem with developers and end users, ecosystem for each project. Can approach it as ecosystems within the overall ecosystem.

Dimension	Component	Conceptual modifications	Description
		AD12. In SA: trust for scalability	Trust must be earned from all ecosystem partners to truly be scalable
		AD13. In SA: remove disease profiles	The disease profiles component of the canvas did not make sense in this context.
	Platform design and governance	AD14. Agile	Agile approach to software development is a common approach
		AD15. Technology stack	Technology stack design forms a crucial part of platform design.
		AD16. Establish an MVP	The Minimum Viable Product should be established and pursued as a benchmark.
		AD17. Standards	An overview of relevant standards in the research context.
		AD18. Lowest hanging fruit metaphor	Build the MVP of the easiest, most demanded part first. Subsequently build the MVP for the next level of functionality while obtaining feedback on the first level's MVP.
		AD19. Monetisation components	Add: Charging a transaction fee, charging for access, charging for enhanced access, charging for enhanced curation.
	Managing and operation	AD20. Market entry mechanisms	Different market entry mechanisms, specifically within the SA context. This refers to entering the market through partners, medical aids, businesses etc.
		AD21. Transactional platform issues and solutions	Transactional platforms have several challenges along with solutions not yet discussed. If the framework aims to be truly generalised, these should be added.
		AD22. SA: User adoption and sustainability	Often a 'greater good' company is paying, but end users not using it due to lack of user research and subsequent design.
		AD23. SA: keep data traffic light	The software development should consider methods to keep the data traffic light as connectivity and airtime may be limited.
	Evolution	AD24. Evolution of components	More than one component could evolve: the platform, platform firm, platform projects and platform ecosystem.
		AD25. Bottlenecks	Identify areas, users, technologies, markets, etc. that are inhibiting growth.
		AD26. Develop and apply maturity model	Research relevant maturity models, or develop levels of maturity that can be used to assess the platform and for continuous improvement.

Agile software development (AD22) was continuously mentioned throughout the evaluation process and it was therefore also added to the final framework. Agile is a group of methodologies that incorporates continuous feedback cycles and continuous improvement of software products [204]. Agile is focused on working towards solving the customer's problem and allows for rapid response to changes in marketplaces or as requested by end-user feedback [204]. This approach is particularly useful for a firm that wants to remain innovative in the dynamic digital business environment [205]. Agile software development focuses on quality, cost reduction and reduced deployment time [205], [206]. Cockburn [205] describes the nature of Agile by stating that in this approach "*a complex adaptive system, decentralised, independent individuals interact to create innovative, emergent results*" [205, p.

121]. Therefore this methodology can be potentially beneficial for platform development within the South African Health context.

During the case study, the researcher realised the importance of choosing a 'tech stack' (AD23) prior to application development. A technology stack, or 'tech stack' as it is called amongst developers, is the selected combination of software products and programming languages to develop applications. These applications include both web and mobile applications [207], [208]. Applications can be divided into front-end and back-end components, referring to the client- and server-sides respectively. The front-end is the section of the application that end users will see and interact with. The back-end section comprises of the business logic that drives the application and is not seen by the end user. Therefore, the front end transforms the back end into a readable and usable format. Each of these two sides has different layers that collectively form a stack as shown in Figure 91. These different layers build on each other and make up the stack for the application [207].

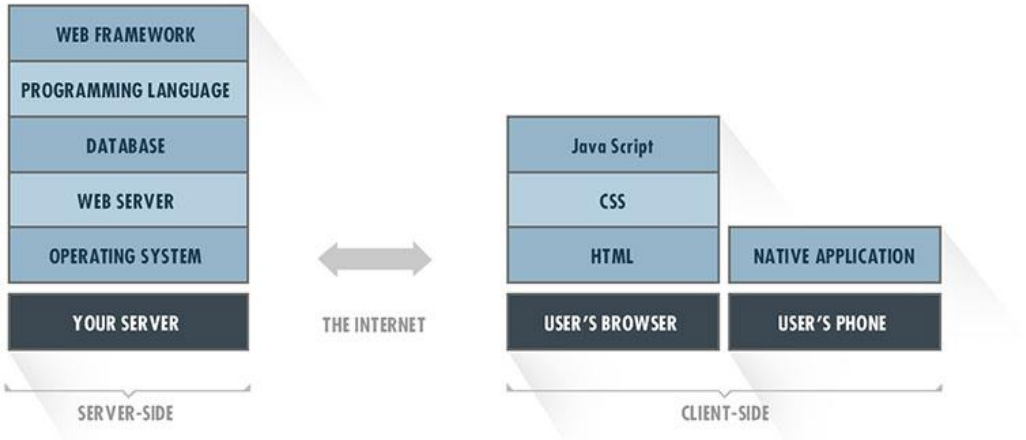


Figure 91: Example of a technology stack [208]

It is important to understand the purpose of the tech stack and how it affects the platform owner's web or mobile applications and their respective development processes. The technology behind the applications influences the way in which the app functions, its scalability, deployment time, user interface and how it can potentially evolve [208]. Platform owners should therefore be aware of the advantages and disadvantages of their selected tech stack. It should be clear whether the selected tech stack aligns with the platform's priorities, needs and future vision.

Standards or Regulations (some overlap)	Organisations for interoperability	Open source healthcare initiatives	Laws, associations or institutions within the South African (eHealth) industry	Tools or strategies available
ISO IEEE SANS CEN DICOM HL7 (CDA CCD) ICD10 SNOMED CT ITU SITA (MIOS, MISS) OASIS RFC3881	Continua Health alliance WHO IHE ASTM International Healthcare Informatics Technical Committee NEMA/COCIR/JIRA Security and Privacy Committee	OpenHIE OpenHIM OpenSHR epSOS DHIS 2	PoPI Act Health systems trust (HST) Health information systems program (HISP) South African Healthcare Informatics Association (SAHIA) South African Telemedicine association (SATMA) State Information Technology Agency (SITA) National Health Information System of South Africa (NHISSA) National Indicator Data Set (NIDS)	SA HNSF National eHealth strategy toolkit mHealth toolkit SA eHealth strategy toolkit PPD Principles for digital development NDOH Data Dictionary

Figure 92: Overview of standards, regulations, organisations, laws, associations, tools and strategies within SA health

The fourth addition included a summary of standards, regulations and other relevant components that can be used as a guide for platform design specifically within the South African Health context (AD25). Figure 92 includes identified standards, organisations involved in interoperability, open source

initiatives providing valuable insight into eHealth implementations, South African-specific associations and institutions and available tools or strategies which aim to advance the uptake of eHealth, mHealth and digital health applications. As a platform owner it is important to be aware of which of these components relate to the platform and ecosystem.

Following the investigation into Mezzanine (both a transactional and innovation platform), the researcher realised that in order to develop the desired generalised framework, certain transactional platform issues need to be incorporated into the framework (AD29).. Tiwana [3] identified principles to guide such platforms. The first principle is called the Red Queen Effect which refers to the case where rival technologies and solutions add pressure on the platform to adapt and increase its evolutionary pace. The second issue is the Chicken-or-Egg dilemma. This dilemma refers to the issue regarding which side of the market to attract to the platform first and how to attract them. The Penguin Problem occurs when potential adopters of the platform resist adopting due to being unsure if others will also adopt. The final dilemma is called Emergence and occurs when certain properties arise as platform participants pursue their own interests.

In particular, the Chicken-or-Egg dilemma has been extensively researched in the literature taking the economic perspective on platforms [11], [34], [142], [209]. Typical strategies to overcome this dilemma include staging value-creation to demonstrate potential benefits from using the platform, to attract one set of users through the platform design, or to design the platform to enable value-creation even with a small network [2]. Parker et al. [2] recommend eight strategies for overcoming the Chicken-or-Egg dilemma and these are summarised in Table 58.

Table 58: Recommendations for overcoming the Chicken-or-Egg dilemma [2]

Strategy	Description
Follow-the-rabbit strategy	Use an existing pipeline or product business to build the platform business and thereby avoid the Chicken-or-Egg dilemma.
The piggyback strategy	Piggyback on another platform to access its user base and thereby recruit participants. For example PayPal that piggybacked on eBay. See also [34].
The Seeding strategy	Develop the platform to attract one set of users. Typically the other set will follow. See also [34].
The marquee strategy	When one group of participants is crucial for platform success, provide incentives to attract these members to the platform. See also [34].
The single-side strategy	Initially start a business that benefits one side of the users. Subsequently convert the business into a platform. This can be done by attracting another set of users.
The producer evangelism strategy	The platform attracts users who are producers themselves. When the producers join the platform, their customers automatically start to use the platform.
The big-bang adoption strategy	Attract large volumes by using a traditional push marketing strategy.
The micro market strategy	Identify a small market that comprises members that are already interacting. Grow this market via the platform.

The final description refers to the evolution of the different components in the ecosystem (AD32). Gaining insight into Mezzanine's evolution, the conclusion could be made that the platform itself, the platform owner firm, the projects built on the platform as well as the platform ecosystem could evolve and all in different ways. A platform owner should therefore not only focus on evolving one of these elements, but co-evolve them all. The platform itself could evolve via feedback from end users, developers and external influences such as emerging technologies. The platform owner firm could evolve in terms of its vision, short-term and long-term goals and its internal structure. The projects built on the platform should be updated based on user and client feedback. The platform owner should also work to evolve the platform ecosystem by encouraging network effects, adding new ecosystem

partners or broadening its scope into other functionalities or industries. This concludes the modifications as a result of the case study evaluation.

8.8.3 Usefulness of framework

The tool proved to be useful and all interviewees agreed that at a minimum the Platform Owner Canvas and the Platform Development Canvas would be useful to a platform owner. The researcher also presented the framework to the executive board of Mezzanine as per request of the CEO. The CEO highlighted the importance of considering both economic and engineering platform perspectives.

8.8.4 Reflections on Mezzanine Ware

Subsequent to the case study on Mezzanine Ware, the researcher had a sound understanding of their platform and business approach. Mezzanine is particularly good with designing for their end users. The back-end through to the front-end design, development and actual implementation of the applications are all done with a user-centric focus. Building on top of their PPP model, the deliberate effort to accurately meet the needs of all end users adds to Mezzanine's success. Mezzanine also does not follow a one-size-fits-all approach for their products. They currently have 15 different products and they treat each product as a business on its own; with its own Mezzanine team and custom business model. However, this provides the reason for Mezzanine's monetisation challenges. Mezzanine currently has to develop a personalised monetisation for each solution. Their challenges continue in terms of external developers, where there is currently not a set monetisation strategy. The Helium development language that is unique to Mezzanine is a significant entry barrier if Mezzanine intends to actively build its external developer ecosystem.

Mezzanine also has several feedback lines from ecosystem actors which enables them to continuously evolve the platform. This is supported by monitoring mechanisms both in the platform and through diverse communication channels. As a part of their evolution strategy, they are already actively working for future goals and priorities. They are investigating their current industries to identify possible partners to enable collaboration and to build towards their goal of being a comprehensive platform of platforms. Therefore Mezzanine's evolutionary strategy is also admirable.

8.8.5 Reflecting on a technology platform in a developing country

The initial framework was essentially formulated by investigating literature on predominantly first-world countries. This is because most of the available literature on technology platforms does not explicitly consider its operation beyond first world countries and how this may influence the design, development and implementation of the platform. Therefore, a contribution of this framework is the insight into how such a platform will function in a developing country such as South Africa. However, these additional insights were only obtained during the evaluation stages of framework development. This also calls for more research on implementing technology in developing countries as there is a clear gap. The interviews and case study have proven that the typical design, development and implementation approaches need to be adapted for this context. A summary of all considerations for this context will be discussed in the following chapter.

8.9 Chapter 8 conclusion

Chapter eight concluded the evaluation of the framework. The evaluation process described in this chapter comprised a case study on an existing technology platform firm that operates in the South African Health context. An overview of the case study approach was given, followed by an overview of the case study firm, Mezzanine Ware. Thereafter the case study findings and how it related to the framework were presented. The subsequent modifications and additions to the framework were indicated and discussed. The final framework and management tool will be discussed in the next chapter.

Chapter 9: Final framework and management tool

Chapter 9 key objectives:

- Give a concise background on the framework and tool
- Evaluate the final framework in terms of the criteria from Section 4.8
- Introduce the final management tool
- Describe the dimension one canvasses
- Describe the dimension two canvasses
- Highlight the tool's use in the South African health context

9.1 Introduction

Chapter 9 presents the final framework and management tool that was developed to meet the project objectives. Figure 93 indicates the progression of the study with relation to the Research Design. The framework evaluation process is indicated in Figure 94. The framework formed the outline of the tool and the tool is the version of the framework that can be readily applied and used. This chapter gives a summary of the background and motivation of the tool. The objectives and aims of the tool are also discussed and its success in meeting these evaluated. The final tool is discussed thoroughly including the ecosystem and platform development dimensions. Specific attention is also given towards how the tool relates to the South African health context.

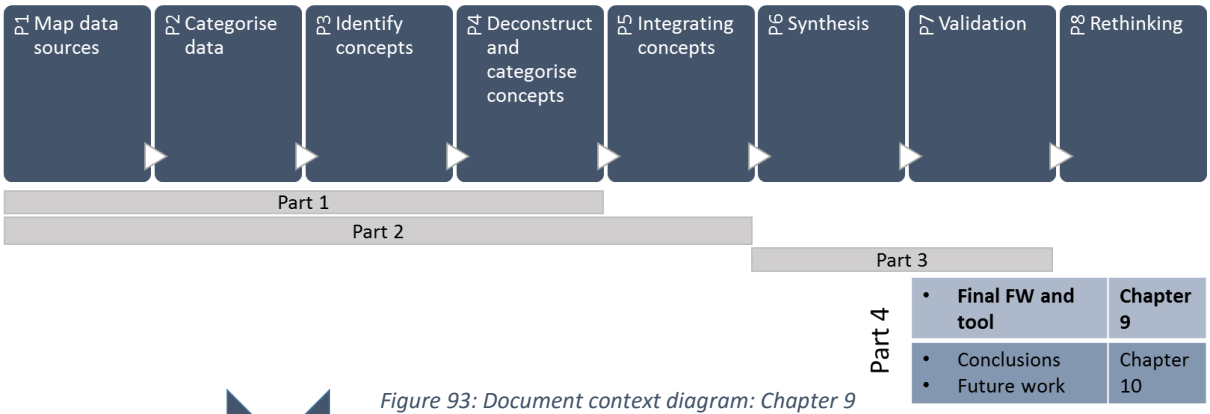


Figure 93: Document context diagram: Chapter 9

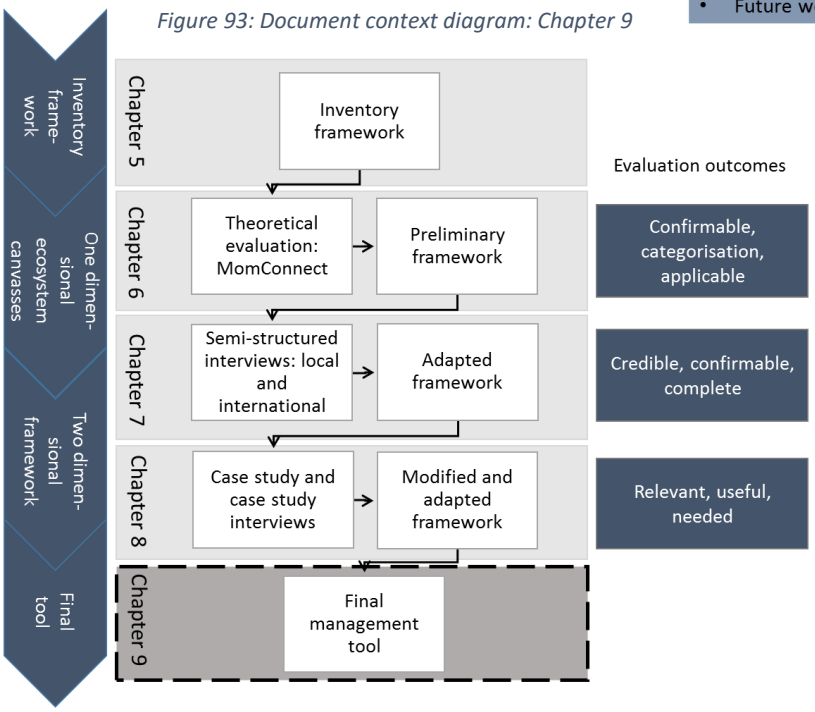


Figure 94: Overview of Chapter 9 context in the framework evolution and evaluation process

9.2 Tool background and motivation

The motivation for the development of this tool is built on two components: (1) the need for increased adoption of health platforms in the South African health context and (2) the challenges faced by platform owners. Inspired by the Sustainable Development Goals 3 and 9, innovations such as technology platforms can provide useful solutions within South African health. Therefore, this framework aims to facilitate the use of an innovative technology to provide solutions for increased health and well-being, as shown Figure 95. As this chapter presents the final tool, it aims to be a stand-alone chapter and may therefore repeat certain segments that has been included in this document previously.

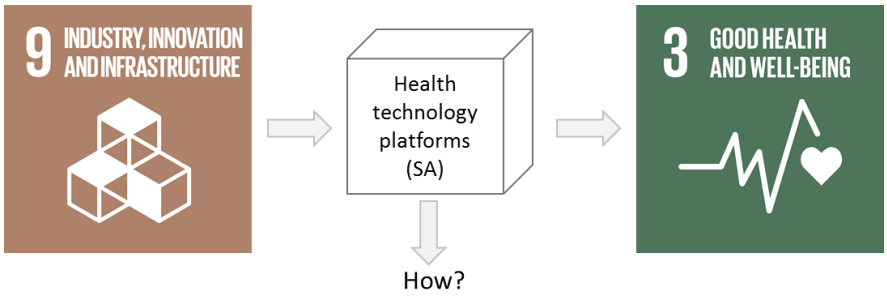


Figure 95: Context of the motivation of the framework

South Africa has numerous health-related challenges. Access to healthcare, quality of healthcare services [32], the growth of non-communicable diseases, [8] the current nurse-based public health system [6] and the reality of HIV and TB related deaths [31] illustrate the need for health-related solutions. Innovative technologies such as technology platforms can provide solutions to some of these challenges. Technology platforms can collect data and communicate information, improve remote monitoring of patients, enable patient self-education and contribute to general improved efficiency and point of care services [8], [28], [29], [30], [31]. As a result, the researcher aimed to develop a framework that could facilitate in the adoption of technology platforms as solutions to the much-needed health system challenges.

The second motivational factor for the framework was the complex task of being a platform owner. Platforms differ from traditional linear businesses and therefore require unique management strategies [3]. Some of these differences include digital value creation and distribution [14], the ability to collect and analyse vast amounts of data [14], platforms often being multi-sided [13], the scalability of platforms [3], ecosystems forming around platforms and the need for rapid and continuous evolution [14]. Compounding the change in traditional management strategy, platform owners also face several challenges with regard to their platform. Platform owners need to determine the platform openness in terms of the technology and interfaces [15], balance control mechanisms within the platform and ecosystem [15], provide support for all levels of the ecosystem, be aware of its entry and exit barriers and fairly create and distribute value within the ecosystem [3].

The environment, ecosystem and nature of a platform and its ecosystem result in challenging tasks for platform owners. Therefore, the aim was to develop a tool that can aid platform owners in this task and thereby potentially increase the adoption of technology platforms within the South African health context.

9.3 Tool design summary: Methodology and evolution of tool

The framework was developed following the CFA approach proposed by Jabareen [39]. As discussed in Chapter 2, this process comprises of eight phases that guide the researcher in developing a framework. This process was followed and adapted in order to develop the proposed framework and management

tool. Figure 96 indicates an overview of the Research Design followed to develop the framework and tool and how it relates to the CFA process.

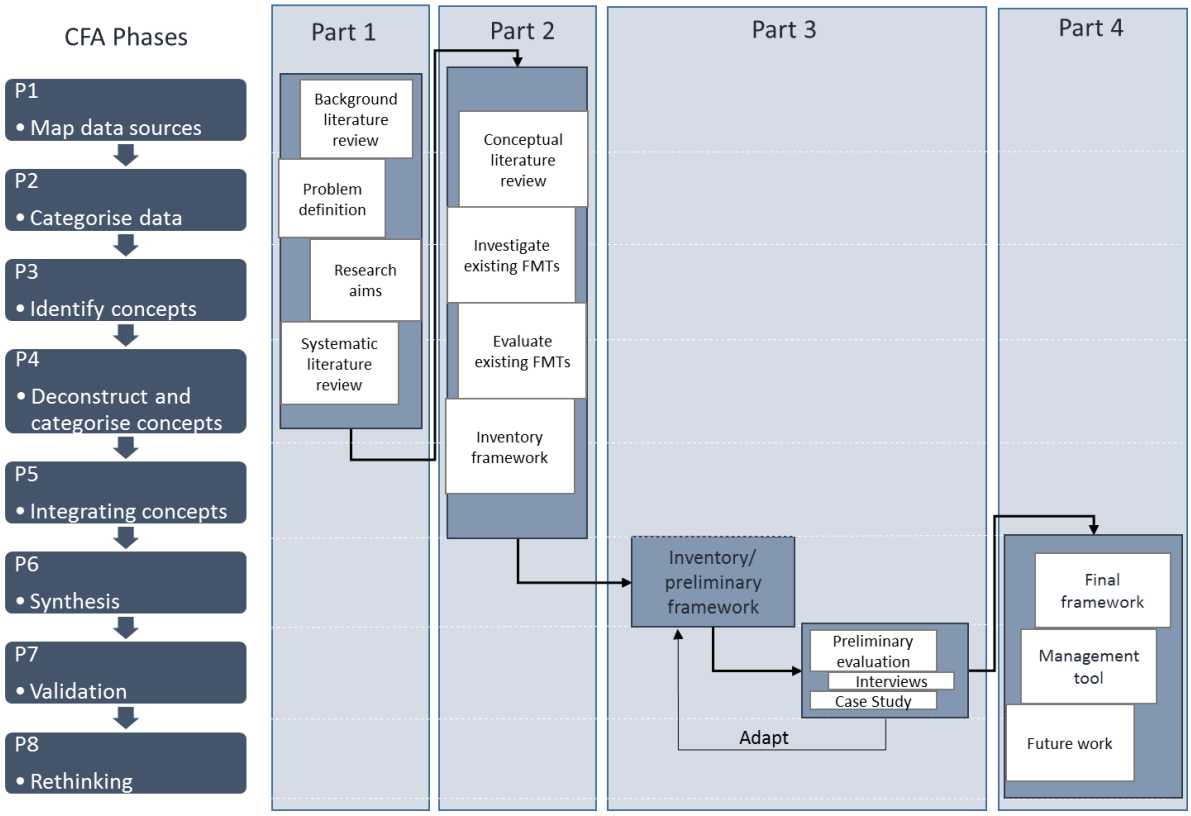


Figure 96: Reflection on the study Research Design

As described previously, the framework development process was divided into four parts. Part 1 focused on establishing the research aims and making sense of the literature. The components of this part included a background literature review, defining the problem and subsequent research aims and objectives and a systematic literature review. Part 2 comprised the formulation of the inventory framework which was the basis of the final framework. The inventory framework resulted from a systematic literature review and an in-depth conceptual literature review. The conceptual literature review included investigating and evaluating existing frameworks, models and tools related to this research. The inventory framework was evaluated and evolved in Part 3 of the study. This included a theoretical application of the framework, semi-structured interviews and a case study. The framework was evaluated and adapted after each of these elements, respectively. Finally, Part 4 of the study included formulating the final framework and resulting management tool.

9.4 Evaluating the proposed tool against predetermined criteria

The proposed tool aims to be a facilitative tool for platform owners in the design, development and implementation processes of their platforms and the subsequent management of their platform firms and ecosystems. The tool was built to be generalised in order to be used for different types of platforms. The tool also draws from both platform perspectives, namely the engineering and economic perspectives. There are four main aims of the framework: (1) to be a practical management tool for platform owners in the South African health context, (2) to encourage a user-centric focus regarding both developers and end users, (3) to address specific challenges that ecosystem actors encounter and (4) to combine both the engineering and economic views on platforms.

In Section 4.8, the researcher formulated criteria that the envisaged framework should meet and used these to direct the investigation and evaluation of existing frameworks, models and tools (FMTs). These criteria were segmented into three stages. The stage one criteria were derived from the original

project objectives and research questions. The stage two and three criteria were formulated subsequent to the previous literature study elements. These included certain core concepts to be included in the framework. Table 59 indicates the objectives and research questions for this study, how this was translated into key criteria components and how the final framework relates to the components.

Table 59: Comparing the final framework to the criteria developed in Section 4.8

	Research objective or question	Key components for criteria	Framework ranking
Research Objectives	RO1: Review the fundamental concepts of technology platforms from an ecosystem perspective through conducting a systematic literature review.	Technology platform characteristics Ecosystem	✓
	RO2: Establish the context and requirements of technology platforms within their ecosystems and the dynamics with their ecosystem partners though conducting a conceptual literature review.	Requirements of technology platforms in ecosystem Dynamics within ecosystem	✓
	RO3: Investigate and assess current frameworks, models and tools relevant to platform and ecosystem management	Frameworks, Models Tools	✓
	RO4: Deduce a preliminary theoretical framework or method to be followed to aid in the design, development and implementation of these platforms.	Platform design Platform development Platform implementation	✓
Research Questions	What are current design strategies and requirements for platform development?	Platform design Platform design requirements	✓
	What are technology platforms and their key characteristics?	Technology platform characteristics	✓
	How do technology platforms relate to platform ecosystems?	Technology platforms Platform ecosystems	✓
	What are platform ecosystems and their key characteristics?	Platform ecosystem characteristics	✓
	What are the benefits of health technology platforms?	Health platforms	✓
	What are the principles of evolution of these platforms within their ecosystems?	Platform evolution Platform ecosystem evolution	✓
	What would a management tool for technology platforms look like?	Management tool	✓

The stage two and three criteria from the literature study are shown in Table 60. It also indicates in what part of the framework the criteria are met.

Table 60: Referencing the framework components to the criteria developed in Section 4.8

Element of consideration		The final framework and applicable elements
General information	Framework or model, tool	Framework and tool
	Type of platform	Transaction and innovation - integrated
	Layout	Canvasses
	Research area	Multidisciplinary
Criteria	Platform design	Whole framework
	Management aspects	Whole framework
	Evolution	Platform development canvas, Ecosystem canvasses
	Life Cycle/ maturity	Platform development canvas, Platform owner canvas
	Ecosystem	Whole framework
	External environment	Platform development canvas, Platform owner canvas
	Value creation	Platform development canvas, Ecosystem canvasses
	Governance	Platform development canvas, Ecosystem canvasses
	Architecture	Platform development canvas, Ecosystem canvasses

Element of consideration		The final framework and applicable elements
	User focused	Platform development canvas, Developer and end-user canvasses
	Competition	Platform developer canvas, Platform owner canvas
	Openness	Platform development canvas, Platform owner and developer canvasses
	Control	Platform development canvas, Ecosystem canvasses
	Entry barriers	Ecosystem canvasses
	Pricing/ revenue model	Platform development canvas, ecosystem canvasses
	Ecosystem health	Platform development canvas, platform owner canvas
	Actor roles	Platform development canvas, platform owner canvas
	Design rules	Platform owner canvas, developer canvas
	Practical elements	Whole framework

The framework was specifically developed to meet these criteria. It can therefore be concluded that the framework meets the stage one, two and three criteria sufficiently. The framework comprises all the key components and themes from the project objectives and questions. The concepts included in the stages two and three criteria were derived from multiple research streams such as ecosystem, management and software engineering and development research. These concepts also directed the framework development process and could successfully be incorporated into the framework.

9.5 The proposed management tool

The proposed management tool comprises of six canvasses shown in Figure 97. The first canvas in Figure 97 is the Overview Canvas which gives an overview of the complete tool and its dimensions. The remainder of the canvasses are divided into two dimensions, namely the ecosystem dimension and the platform development dimension. The sixth canvas is the Pre-use Canvas that includes information regarding the tool and considerations regarding the platform that should be noted prior to tool use.

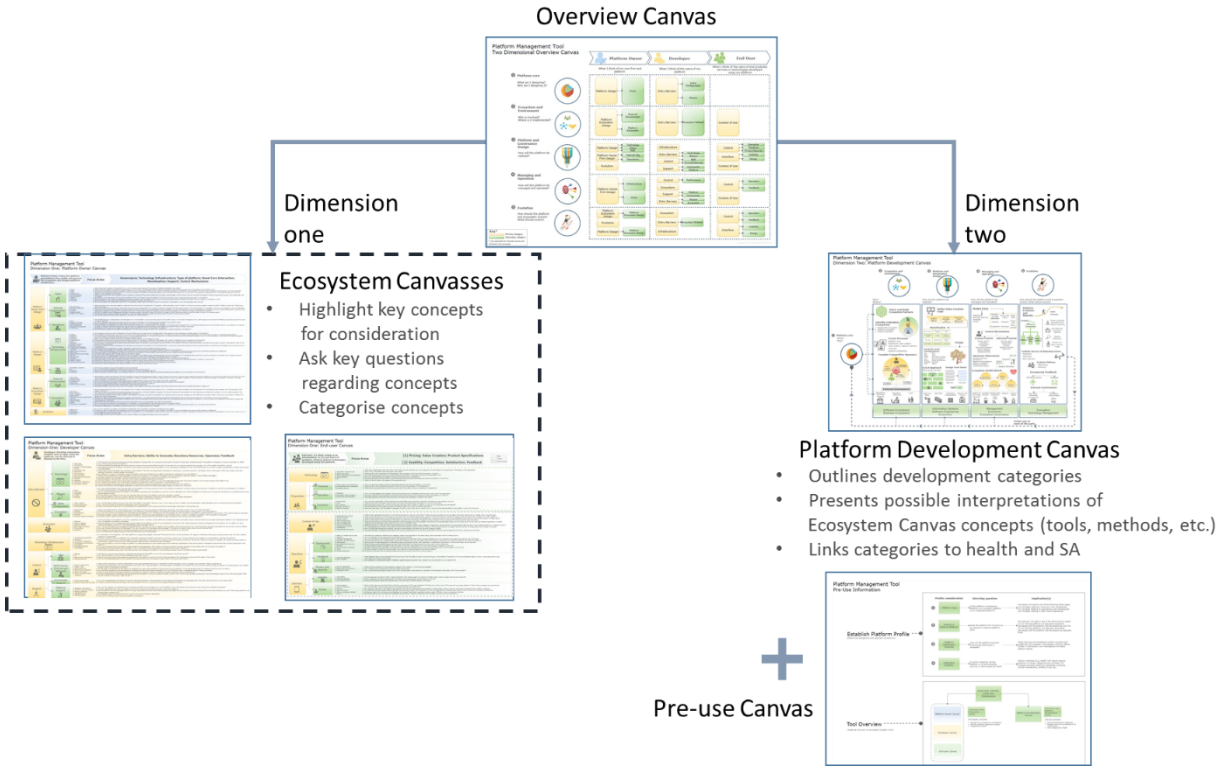


Figure 97: Overview of the dimensions and canvasses in the final tool

The canvasses are intended to be used by the platform owner when designing, developing and implementing its platform and managing the subsequent ecosystem. The tool provides vital

information regarding the platform and ecosystem actors that the platform owner should consider. The final canvasses are discussed next and they are included as full sized A3s at the end of this chapter.

Similar as with the Evaluated and Adapted Framework in Chapter 7, it should be noted that the text included in the canvasses are meant to be concise and are therefore not always complete sentences. The focus was to keep all sentences as short as possible while still conveying the significant ideas and accomplishing the intended purposes. Also, definitions and occurrences of the concepts in the framework and subsequent tool may overlap in reality.

9.5.1 Pre-use Canvas

Platforms can refer to several different things in literature and in industry. Throughout the framework evaluation process, the researcher realised the importance of clearly defining the platform profile as it will influence the lens through which the framework is viewed. In order to define the platform profile prior to framework use, the framework commences with the Pre-use Canvas. This canvas aims to guide the platform owner through establishing the profile for his own platform. Four platform profile factors were found to influence the approach towards the framework: (1) the platform type, (2) whether the platform is an internal or external platform, (3) the platform distribution channels and (4) the application industry of the platform.

Each of these components has implications for the framework. The platform type establishes whether the platform is a transaction platform, an innovation platform, or an integrated platform. The framework's approach is to be as generalised as possible and thereby it combines these two approaches. Subsequent to establishing the platform type, either the elements relating to the economic platform perspective, relating to the engineering perspective of platforms, or relating to both these perspectives would be emphasised. The second profile consideration refers to the platform being internal or external. In the case of an internal platform, the developers are part of the platform owner firm. Therefore, the Developer Canvas will be applicable to the platform owner firm itself. In the case of an external platform, the developers are external to the platform owner firm. In this case the Developer Canvas should be approached accordingly.

The following two considerations are the platform distribution channels and the application industry. The platform distribution channels refer to how the developers and end users will access the platform and its end products or services. The end users could access the end products or services through several different marketplaces. The framework consists of a number of marketplace-related concepts and therefore their importance and interpretation would depend on the platform distribution channels. The final consideration is the application industry. The framework was developed to be applicable to other industries whilst its main focus was on health. Therefore several concepts within the framework will be emphasised for health and possibly not for other industries. The Pre-use Canvas also gives a visual overview of the tool, the purposes of the canvasses and how they all link together in the Overview Canvas.

9.5.2 Overview Canvas

The framework comprises of two dimensions, namely an ecosystem dimension and the platform development dimension, however these dimensions are not mutually exclusive. The elements from both canvasses overlap and can be linked. The Overview Canvas has three functions. Firstly, the focus of the Overview Canvas is to show how these two dimensions overlap and thereby give an overview of the framework content. The Overview Canvas therefore comprises the platform development parts as the rows and the ecosystem actors as the columns. At the intersection of the two dimensions, the canvas includes the relevant categories and subcategories from the Ecosystem Canvasses. These primary and secondary categories highlight important considerations at each respective intersection point.

Secondly, the Overview Canvas acts as a reference guide by which the platform owner can navigate through the remainder of the framework. An example is illustrated in Figure 98: if the focus is specifically on the end user (column 3) and the platform and governance design part (row 3), the Overview Canvas can be used to guide the platform owner where to focus his attention within the framework canvasses for more information. Figure 98 indicates the intersection point (dotted red) on the Overview Canvas and how it refers the framework user to the correct ecosystem canvas categories.

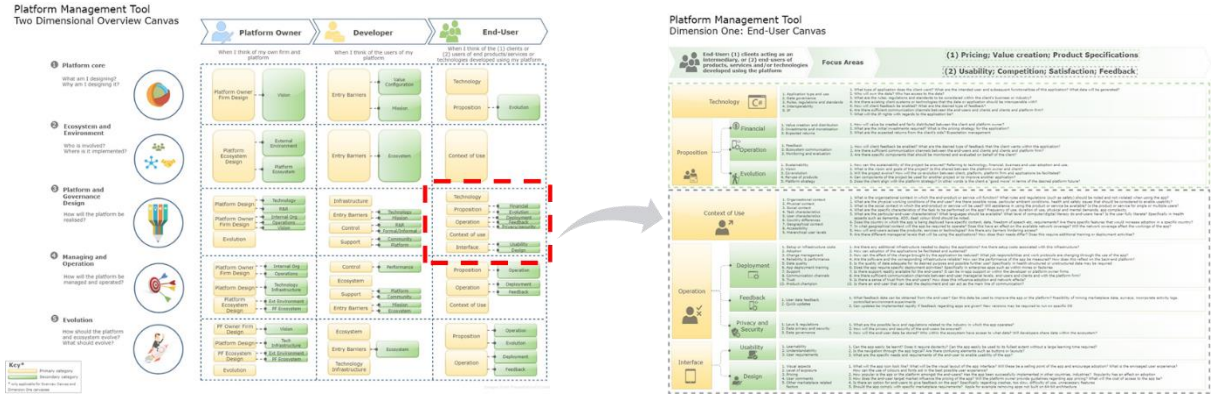


Figure 98: Illustration of one use of the overview canvas

Thirdly, the Overview Canvas can also be used to understand platform design, development and implementation on a high level. The primary and secondary categories on this canvas were selected to be descriptive in order to provide understanding on a high level. By understanding the two dimensions and their intersection points, the platform owner can potentially develop his own, customised breakdown of these primary and secondary categories. The platform owner therefore does not have to be limited to the category breakdown given in the remainder of the framework. Following this Overview Canvas are the dimension one Ecosystem Canvasses.

9.5.3 Dimension One: Ecosystem Canvasses

The initial framework was developed to only comprise canvasses for the three ecosystem actors as initially identified in the analysis of the systematic literature review data in Section 3.6.3. Building on the systematic literature review results, the ecosystem was divided into the platform owner, the developers and end users. The platform owner referred to the owner of the platform and its software components and IP rights. The developers were defined as either the internal or external actors who innovate on top of the platform. The end users at that stage (Chapter 3) referred to the end users of the products, services or technologies that were developed using the platform.

As a result of the insight gained into the South African and health contexts during the evaluation process, the end users of the final framework were redefined. The end users are now defined as either: (1) the client (intermediary) requesting the products, services or technologies, or (2) the actual end users using these products, services or technologies. In the case where no client is involved as an intermediary, the end-user canvas can still be used as defined initially.

During the evaluation stage of the framework development process, a second dimension was added to the Ecosystem Canvasses, namely the platform development parts. Subsequently the final framework is two-dimensional. The ecosystem dimension includes the Platform Owner, Developer and End-user Canvasses.

The layout of the Ecosystem Canvasses is shown in Figure 99. It includes the definition of the ecosystem actor, key focus areas of this ecosystem actor, the canvas concepts and their categorisation. The aim of the first two components is to enable a better understanding of the ecosystem actor. The remainder of the canvas content is broken down into main categories, subcategories and relevant concepts. These

concepts are then all translated into questions to direct the platform owner's thoughts and subsequent actions. As all platforms are unique, thought-provoking questions were selected as the appropriate way to further interpret the concepts. Thought-provoking questions do not limit or constrain the user to a specific answer or type of platform. As mentioned previously, the text in the canvasses are meant to be concise, whilst still conveying the required information and are therefore not always full sentences.

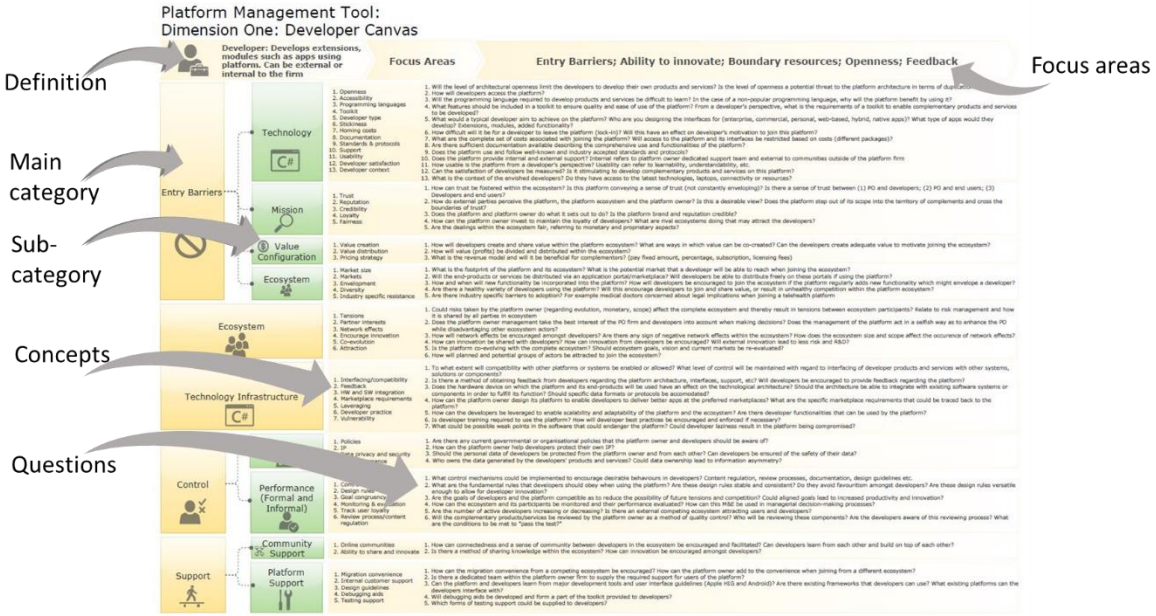


Figure 99: Illustration of an Ecosystem Canvas' layout

9.5.3.1 Platform owner Canvas

The platform owner refers to the owner of the platform who governs the platform ecosystem and is responsible for the design and evolution of the software. Therefore, this canvas also includes the technology platform aspects. Specific focus areas of the platform owner include governance, the technology infrastructure, the core interaction, functionality of its platform, monetisation, support and control mechanisms. The definition and focus areas of the platform owner are included as a part of the Platform Owner Canvas. The Platform Owner Canvas aims to inform a platform owner what to consider regarding his own firm, platform and the ecosystem forming around its platform. The user of the canvas should approach it by putting on the 'platform owner's hat' as shown in Figure 100.

Figure 100: Putting on the platform owner hat for the Platform Owner Canvas

The Platform Owner Canvas comprises four main categories that have proven to be key in the design, development and implementation processes. The first category refers to the platform owner's own firm and the design thereof. Within this category, the concepts were grouped according to their respective relations to the platform vision, the internal organisation and the operations within the firm. The platform vision includes concepts concerning the core of the platform, its purpose and future trajectory. The second category comprises the platform design with two subcategories. These two subcategories refer to the technology infrastructure and corresponding rules and regulations. Technology infrastructure specifically includes the technical and software considerations of the platform. Next, the platform ecosystem considerations relating to the platform's ecosystem and its external environment are included. The external environment focus on competition and it emphasises

the need to look outside of the platform and ecosystem for sustained success and evolution. The final category for this canvas includes the evolution of the platform. Subsequent to understanding of the platform owner's key concepts, the Developer Canvas follows.

9.5.3.2 Developer Canvas

The platform owner needs to put on the 'developer hat' when using the Developer Canvas and understand what developers' characteristics and needs are regarding the platform and ecosystem as shown in Figure 101. The developers refer to the actors that are developing the extensions or modules such as applications using the platform. As discussed in the Pre-use Canvas, the developers can either be internal or external to the firm. Key focus areas of developers include the platform and ecosystem entry barriers, how well the platform enables them to innovate, the availability of boundary resources, how open these boundaries are and the ability to provide feedback regarding the platform.

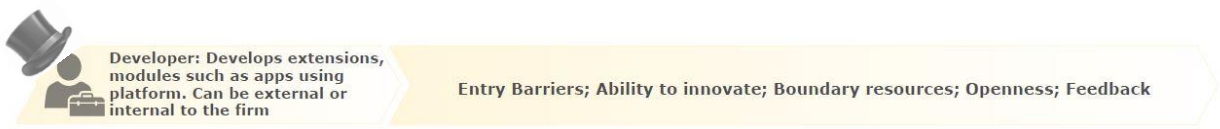


Figure 101: Putting on the developer hat for the Developer Canvas

The Developer Canvas is divided into five main categories that aim to provide a general understanding of what a platform owner should consider with regard to the developers using his platform. The first category refers to the entry barriers. The entry barriers are those factors that would either cause a developer to resist joining the platform or encourage them to join the platform. The entry barriers were categorised according to their relation to the platform technology, to how the platform firm is perceived (mission), how value will be configured within the ecosystem and what the platform ecosystem looks like. Subsequent to the entry barriers, are the general ecosystem considerations. These refer to how the platform owner should manage and govern the developers within the ecosystem.

The final three categories refer to the technology, control and support. The technology infrastructure includes what should be enabled or considered regarding the developers. Fourthly, the canvas elaborates on the control the platform owner should have in place. This specifically refers to the rules and regulations and to informal and formal control mechanisms. The final category is developer support. The support provided to developers can be from external developer communities or through the platform and platform firm itself. The common purpose of all these categories is to enable and encourage developers to develop complementary products, services or technologies for end users.

9.5.3.3 End-user canvas

Figure 102: Putting on the end-user hat for the End-user Canvas

The final Ecosystem Canvas focuses on the end users and consequently the platform owner should adopt the 'end-user hat' when viewing this canvas, as shown in Figure 102. The end users portrayed in the canvas comprise two components: (1) a client acting as an intermediary between the platform owner and (2) the actual user of the product, service or technology developed using the platform. The canvas is therefore split according to these two components. In the case of no client being present, the remainder of the canvas can still be used as normal. The focus areas of the client typically include the price of the initiative, how value will be created through it and whether their specifications are being met. The actual users of the products, services or technologies typically focus on its usability in

their context, other similar products available, user satisfaction, its sustained adoption and enabling user feedback.

The canvas layout includes dedicated sections for both of the client and actual end user respectively. The client component of the canvas is presented first and covers two main categories of interest. The first category refers to the technology requirements. This includes determining the requirements of the product, service or technology as well as its specifications. The second category refers to the suggested plan of action, specifically with regards to the financial considerations, the operation of the product, service or technology and its evolution. The categories for the actual end-user component include the context of use, operation of the product, service or technology and its user interface. Thoroughly investigating the context of use is crucial for success.

The platform owner should be informed regarding all deployment-related activities, enabling and incorporating feedback and focus on complying with all privacy and security standards and protocols. These considerations cover the major operational factors with regards to the end users. The final category is the interfaces of the products, services or technologies. Detailed attention should be given to the usability and general design of the front end as this directly influences the success of adoption and the potential subsequent health-related improvements.

This concludes the dimension one canvasses of the framework. The following canvas to be discussed is the Platform Development Canvas.

9.5.4 Dimension Two: Platform Development Canvas

The second dimension of the framework includes the Platform Development Canvas. The Platform Development Canvas was not a part of the initial framework, but was added subsequent to the semi-structured interview phase of the evaluation process. It comprises five parts: (1) platform core, (2) ecosystem and environment, (3) platform and governance design, (4) managing and operation and (5) evolution. The Platform Development Canvas' layout includes the five parts of platform development, additional SA health considerations and relevant literature for each development part. Figure 103 clarifies the terminology used in the discussion of the Platform Development Canvas.

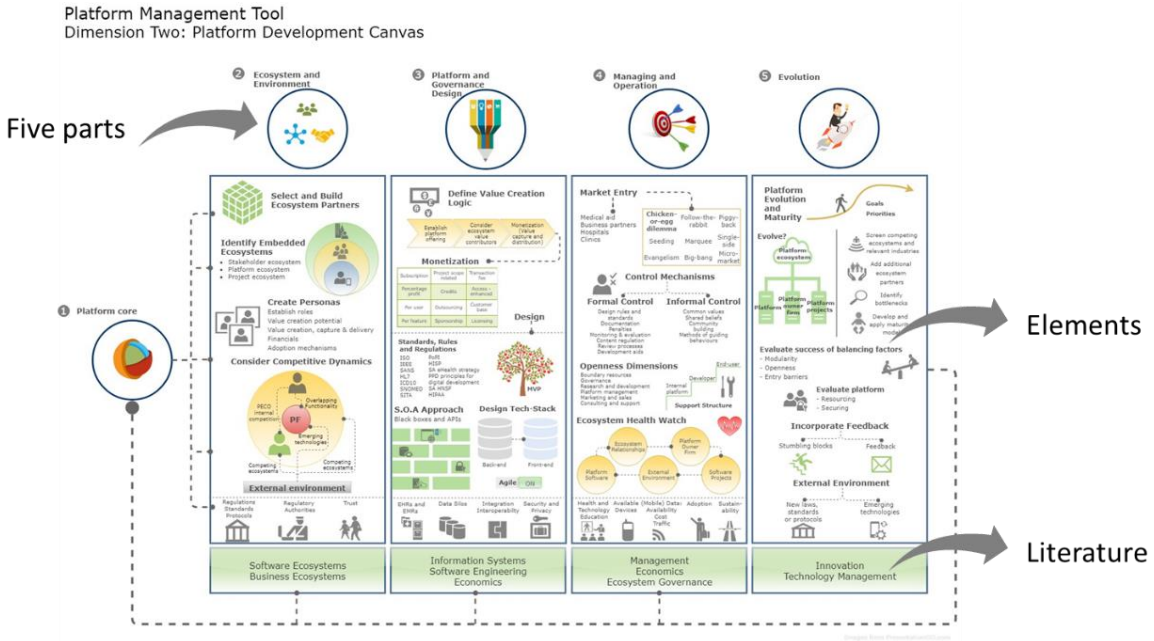


Figure 103: Clarification of terminology used in Platform Development Canvas discussion

The canvas has three overarching aims. The first aim of this canvas is to facilitate the development of a strategy for the platform design, development and implementation as the canvas guides the platform

owner through the typical development parts. Secondly, where the Ecosystem Canvasses educate the platform owner on various topics, the Platform Development Canvas gives structure to their implementation. The final aim of this canvas is to inform on practical and actionable elements that draw from the Ecosystem Canvasses. In other words, it also provides possible interpretations of the dimension one canvasses. The Platform Development Canvas can also be used for software products developed on the software platform. This was illustrated in the case of Mezzanine Ware with the SVS developed on the Helium platform. The Platform Development Canvas can be used for the development of the Helium platform, as well as the SVS. It should however be noted that some elements of the canvas might not be applicable during this use case.

The difference between the framework's two dimensions can be illustrated with an example: the ecosystem dimension Developer Canvas emphasises control mechanisms and asks subsequent open-ended questions. This is indicated in Figure 104 with the blue dashed box. The Platform Development Canvas places control mechanisms within the managing and operation part of platform development (i.e. gives context) and provides a list of formal and informal control mechanisms as indicated by the red dashed box in Figure 104.

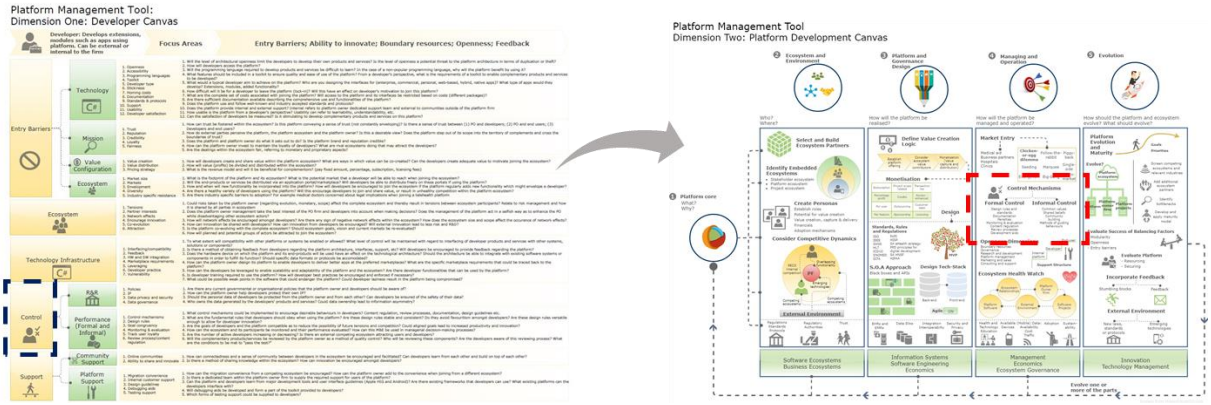


Figure 104: Example of relation between Ecosystem Canvas and Platform Development Canvas

Another example can be taken from the Ecosystem Canvasses where evolution is highlighted as an important consideration and relevant open-ended questions asked. The Platform Development Canvas' evolution part includes several approaches in which a platform, platform firm, platform ecosystem or platform project can evolve. All these practical interpretations included in the Platform Development Canvas either draw from specific literature sources or from data obtained from the framework evaluation phases. An explanation of each of the platform development parts is included next.

9.5.4.1 Platform core

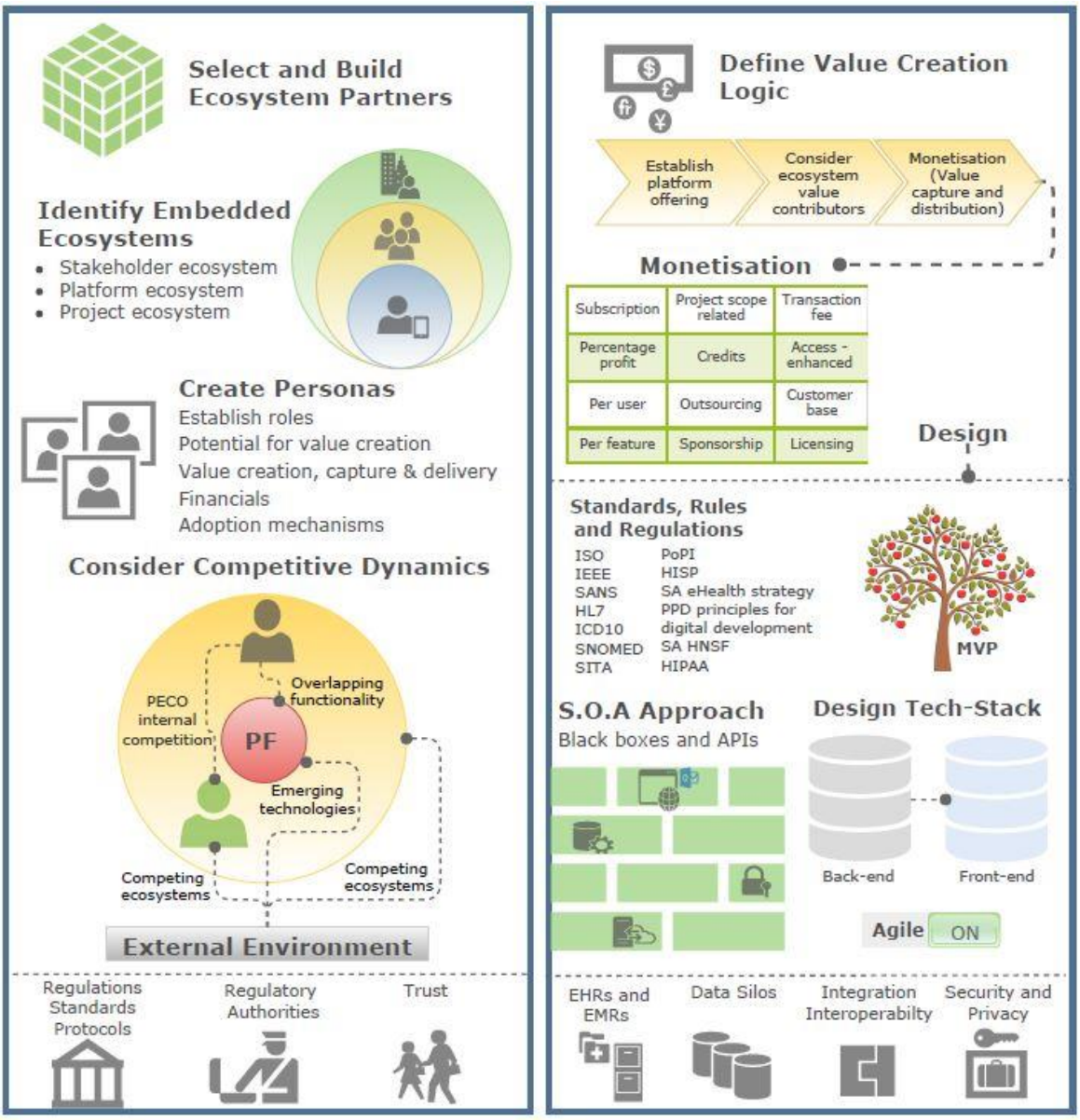
The first part of the Platform Development Canvas is the platform core. The platform core refers to the 'what' and 'why' questions regarding the platform and forms the foundation of the platform design, development and implementation process. This part of the canvas does not have any additional elements added to it. It visually illustrates how the remainder of the platform development flows from this core idea and purpose behind the platform.

9.5.4.2 Ecosystem and environment

The second part refers to the ecosystem and environment and aims to answer the 'who' and 'where' questions regarding the platform. The main components of the ecosystem and environment and platform and governance design parts of the Platform Development Canvas are shown in Figure 105.

** Please note that the software used to draw the canvasses leaves a slight blur on the images if they are not exported as PDFs. Therefore Figures 105 and 106 have slightly blurred text. Please refer to the A3 size Canvasses at the end of this chapter for clearer text.*

The Ecosystem and environment category considers the platform ecosystem and external environment of the ecosystem. The main literature areas that this part relates to are software and business ecosystems. The ecosystem and environment part comprises five main elements of which the final element relates to SA Health within the ecosystem and environment context. The first element highlights the need to actively select and build the ecosystem and select partners. This could be interpreted as identifying and attracting the main partners needed to successfully design, build and implement a software platform within the SA health context. These partners may include the NDoH, mobile networks and health workers, for example. The South African health components within this part of the Platform Development Canvas include country-specific rules, regulations and protocols, identifying relevant regulatory authorities and gaining trust within the ecosystem and desired ecosystem actors.



(a) (b)

Figure 105: Platform Development Parts: (a) Ecosystem and environment and (b) Platform and governance design

The second element of the ecosystem and environment part suggests to identify any embedded ecosystems and may not be applicable in all use cases. It urges the platform owner to identify the specific ecosystem required to build and implement a specific product, service or technology. This is called the product ecosystem. It also places the platform ecosystem (platform owner, developer and end user), as initially defined in this research in context. The final possible ecosystem refers to the stakeholders of the platform firm that form a key role in its success and sustainability. The stakeholders may not actively be involved in the software development, deployment or users of end products, services or technologies. However, they do still form a part of the larger stakeholder ecosystem.

The next element emphasises the need to create detailed personas of a specific ecosystem's actors. This comprises establishing the roles of each of the ecosystem actors and determining the value creation potential of each actor respectively. This can be taken further and the value creation, capturing and delivery for each actor investigated. The financial needs, possibilities or contributions of the actors should also form a part of the personas. The final component includes identifying mechanisms that would facilitate or encourage actors to adopt the platform. This also refers to the adoption of the end users of the products services or technologies developed on the platform. Adoption and acceptance are vital for the success of the platform [28].

The final element of the ecosystem and environment part illustrates the competitive dynamics of the platform ecosystem (comprising the platform owner, developers and end users) and its direct external competitive environment. There are five competitive dynamics that are shown in the diagram. Two of these sources of competition are internal to the platform ecosystem: (1) the internal ecosystem competition between developers and (2) the internal competition between the developers and the platform. The remaining three competitive dynamics arise from the environment external to the platform ecosystem: (1) competing ecosystems attracting the current developers, (2) emerging or disruptive technologies threatening the platform, and (3) competing ecosystems threatening the platform ecosystem as a whole.

9.5.4.3 Platform and governance design

The third category in the Platform Development Canvas is the platform design and governance design which aims to answer the 'how' questions. This section considers how the platform will practically be realised and its main elements are shown in Figure 105 on the previous page. The elements included in this part draw from literature on information systems, software engineering and economics. The platform and governance design part comprises three main elements. The first element elaborates on the value creation logic of the platform, the second element expands on the design of the platform and the final element relates to SA health.

The value creation logic and design components form the bulk of this part. The value creation logic process is illustrated and commences with establishing the platform offering, followed by identifying the contributors of value within the ecosystem and concludes with determining how this value will be captured and distributed within the ecosystem. This value-focused element also presents nine possible monetisation strategies that a platform owner could implement. The design section comprises five components. The first component highlights the importance of standards, rules and regulations and provides possible examples. The second component aims to illustrate the lowest-hanging fruit principle for design. This metaphor emphasises to firstly establish all specifications that the end user or client requests and to rank these specifications. Subsequently, the platform owner should start developing the MVP of the lowest-hanging fruit. This refers to the functionality that most of the users prioritise and would use. Subsequent to the deployment of the lowest-hanging fruit's MVP, the development of the following level of 'fruit' commences and its MVP is developed. Simultaneously, feedback from the first MVP is obtained and used to improve the MVP. This process continues until the complete set of 'fruit' or specifications are developed and deployed.

The first of the remaining three design components refer to the Service Oriented Architecture approach. As mentioned in Section 4.4.4, the SOA approach allows for a complex system to be broken down into smaller, manageable parts. These parts act as black boxes and interfaces via APIs. The second design component highlights the need to carefully design a tech stack. This refers to investigating and selecting specific languages and frameworks to develop both the back end and front end of the applications developed on the platform. The final component refers to the agile software development methodology. This methodology is 'switched-on' during the platform and governance design part, and remains active for the rest of the platform life cycle.

South African health considerations form the last part of the platform and governance design part of the Platform Development Canvas. There are four components within this section. The first component refers to the use of EHRs and EMRs as a part of the platform's core functionality and interaction. This however would require specific data types and standards, otherwise all data would operate in inaccessible data silos. Interoperability and integration are therefore key considerations, specifically to integrate with existing databases and systems. The final component highlights the need for explicit security and privacy measures within the health context, such as compliance to the PoPI Act.

9.5.4.4 Managing and operation

The managing and operation part of the canvas includes the largest variety of elements. The elements focus on essential aspects to consider subsequent to the design of the platform. These elements can be thought of as necessary when the platform is operational or 'live'. The main elements of both the managing and operation and evolution parts of the Platform Development Canvas are included in Figure 106 on the next page. The six elements included in the managing and operation part are (1) market entry approaches, (2) formal and informal control mechanisms, (3) openness dimensions, (4) support structure, (5) elements to monitor within the ecosystem and (6) South African health considerations. The overarching literature streams to consult for this part include management, economics and ecosystem governance related literature.

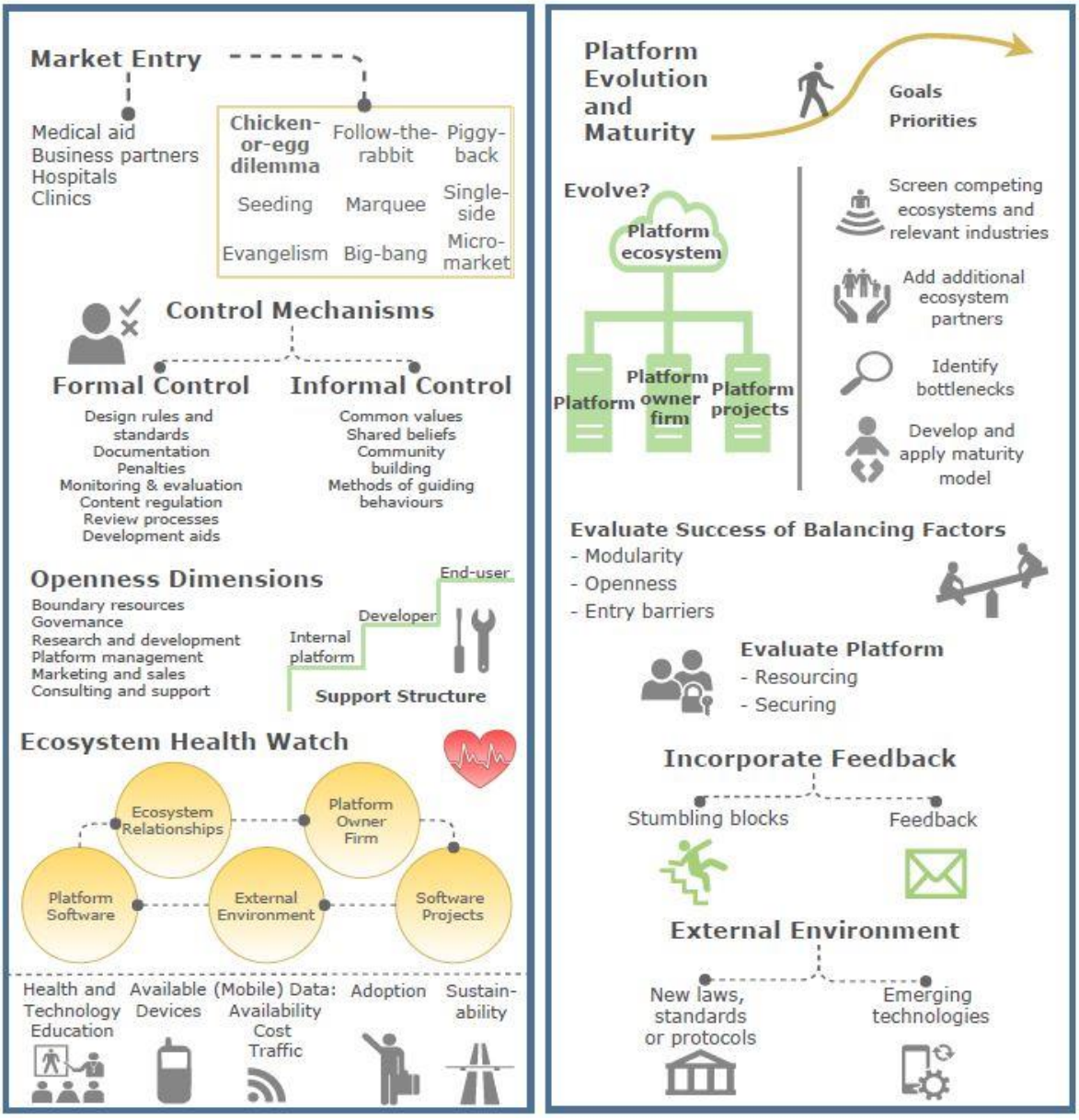
Major challenges that a transactional platform can face relate to its market entry. These multi-sided platforms have to attract more than one type of participant. The participant types are often resistant to join the platform without the other type already being present. Platform owners therefore face the Chicken-or-Egg dilemma, which refers to the problem of which participant to attract first and how they will be attracted to the platform. Eight possible approaches to deal with this dilemma are included as a part of the market entry element. Their descriptions can be found in Table 58 in Section 8.8.2. In addition to attracting the participants required for success, the platform also needs a market entry strategy to initiate network effects. Particularly regarding health this could include partnering with medical aids, hospitals, clinics or with businesses to get access to employees.

The framework evaluation process continuously highlighted the importance of control and support within the platform and ecosystem. The second and third components therefore relate to possible formal and informal control mechanisms and the support structure for the ecosystem. The support structure indicates that there should be specific support provided for each of the platform ecosystem actors. These support elements should all be provided by different teams within the platform firm, depending on the size of the ecosystem and whether the firm operates as an external or internal platform firm.

Two elements that were stressed in the literature reviews were openness and ecosystem health. The fourth element therefore elaborates on different openness dimensions that a platform owner should decide upon. The fifth element of the evolution part comprises five components that should be monitored within the ecosystem in order to cultivate a healthy ecosystem. These components include the platform owner firm, the software projects developed on the platform, the external environment of the platform, the actual software platform and the relationships between the actors in the

ecosystem. Monitoring and evaluation of these components is key for ecosystem health as they are all either directly or indirectly related.

The final element includes five components related to SA health during the managing and operation of a platform and ecosystem. The first component refers to the digital and general literacy and education levels of the end users. The end users may not be educated in the use of technology or how the product, service or technology could solve a health-related issue. Secondly, the end users may have very basic and simple hardware devices. Therefore the product, service or technology should be built taking this into account. The third component highlights the factors associated with data that may influence the design and operation of the application. These factors include the ability to use the application in poor connectivity areas, the additional mobile data costs associated with using the application and the necessity of low data traffic in low network-coverage areas. These factors all need to be considered for the product, service or technology (app) to be effectively used by the end user.



(a) (b)

Figure 106: Platform Development Parts: (a) Managing and operation and (b) Evolution

Methods to facilitate or ensure adoption and sustainability of the application are also vital for its success. Training and change management are some additional factors to implement concurrent to the app deployment. If the use of the application is perceived as complicated, the adoption rate could

slowly decrease and result in failure of the initiative. The sustainability of the application in terms of the technology itself, the financial aspects as well as sustained use should also be considered. There are numerous pilot programs in the South African health context that failed or failed to scale due to lack of investment into these issues.

9.5.4.5 Evolution

In the rapidly evolving digital landscape, technology platforms need to focus on evolution to remain competitive. The final platform development part therefore focuses on the evolution of the platform and its ecosystem. The layout and content of this part of the canvas is structured in a different way than the previous parts of the canvas. The elements included in the evolution part commence with emphasising the evaluation of the platform's maturity, identifying the components that could evolve and providing eight methods of evolution. The literature that could be useful for this part includes literature on innovation and technology management. The main elements of this part is indicated in Figure 106 on the previous page.

The first two elements focuses on establishing the platform maturity identifying components that should evolve. A product or project life cycle S-curve is included to lead the platform owner to identify its current maturity level and its corresponding goals and priorities. The goals and priorities may differ for each of the four phases of the S-Curve. During the start-up phase, the platform owner might focus his efforts on research and development, competition and pricing. The strategy during the growth phase might focus on marketing and the maturity phase on costs and competition. During the declining phase, the platform owner might have to focus on innovation or identify a niche market. The second element highlights the typical components that could evolve. The platform ecosystem, the software platform itself, the platform owner firm or the products, services or technologies developed on the platform could all potentially evolve.

The remainder of the evolution part of the canvas includes eight methods of evolution that were identified throughout the literature study and framework evaluation phases. Firstly, the platform owner could screen competing ecosystems and industries for key trends, marketplace influencers and innovations that competitors are pursuing. The platform owner could also expand the ecosystem by adding additional ecosystem partners to diversify or build the ecosystem. Bottlenecks within the platform, its functioning, development, deployment or adoption should be identified and rectified. A maturity model could also be developed to evaluate different elements of the platform, platform firm and platform ecosystem and identify crucial areas of improvement. The fifth element suggests that the platform owner evaluates the success of the balancing factors, which refer to certain trade-off decisions that were made. These balancing factors can include the modularity of the platform, different openness components and the entry barriers that developers and end users experience.

The remaining three elements of the evolution part was emphasised throughout the literature reviews and the framework evaluation process. The platform should be continuously evaluated to determine the need for additional resources and functionalities. In the case of additional functionalities added to the platform, corresponding supplementary security measures should be implemented. Feedback is a vital source of evolution. The platform and platform projects should be monitored for specific stumbling blocks and effort should be made to minimise or eliminate these stumbling blocks. Other sources of feedback from within the platform firm, the internal and external developers and end users should be obtained to indicate possible areas to evolve. However, the feedback should be prioritised as all feedback should not, or would not be able to be implemented. The final element of the evolution part of the canvas included the investigation of the external environment. In particular, the platform owner should remain up to date on new laws, protocols and standards. Additional security measures could also be added as a result of changes in industry or country rules, regulations or standards. Emerging and disruptive technologies that may influence its ecosystem should also be monitored.

The evolution part of the framework is the final part of the Platform Development Canvas. Following the evolution part, the platform owner could evolve the managing and operation, its platform and governance design, its ecosystem or external environment or the initial platform core. This process is illustrated by the feedback loops that flow from the evolution part of the Platform Development Canvas. The final framework is included after the Chapter 9 conclusion.

9.6 A technology platform in the South African health context

The inventory framework from Chapter 5 was initially developed from literature sources that did not explicitly focus on health or the South African context. Therefore the adaptations specifically for health and the South African context commenced once the evaluation process was initiated. The South African health components of the framework were integrated in both dimensions of the framework. Within the Ecosystem Canvasses, the thought-provoking questions often focus on the implications within the SA health context. The End-user Canvas in particular was modified as a result of the insight gained from the case study. The End-user Canvas therefore separated the client and actual end user of a typical application. Within the South African context this separation commonly occurs as the end users cannot pay themselves or do not understand the benefits that the technology holds. The Platform Development Canvas included more explicit components for the SA health context. These components were added at the bottom of each column. The SA health considerations that stood out during the evaluation process were added and are described in Table 61.

Table 61: Framework inclusions relating to the South African and/or health context

Platform development canvas: SA and/or health	Motivation/ description
Regulations and standards	Health industry in particular has specific regulations and standards that need compliance.
Regulatory authorities	Specifically in the public health sector, the NDoH is a key stakeholder in the ecosystem. Authorities may require specific regulatory compliance.
Building trust	Particularly in rural areas where new technologies are not as familiar, trust may need to be built with users. Also within the government or stakeholders as there is a reputation of 'pilotitis' in SA health (scepticism).
EHRs and EMRs	The platform might need access or enable use of existing EHRs or EMRs.
Data silos	As there are no clear interoperability standards within the SA health context, there are numerous data silos that would require specialised effort to access.
Integration and interoperability	The platform should be designed to be interoperable with other systems or data types.
Security and privacy	The Protection of Personal Information (PoPI) Act is a fundamental part of the platform. Maximised effort should be put into keeping data, such as HIV statuses, secure and private.
Health and technology education	The end users may not be digitally literate. Health education may also be an issue amongst the end users. This affects adoption and use.
Sustainability	Sustainability in terms of funding, as well as adoption and sustained use by the end users.
Available devices	Within the SA context, some types of end users may only have access to very simple and old mobile devices.
Adoption	As technology may not be familiar for all, adoption might be difficult for some end users.
Data availability and cost	In rural areas the end users may have limited connectivity and may not be able to afford mobile data.
Data traffic	Due to limited connectivity in some areas, heavy data traffic may prevent the end users from using the application or from storing valuable data during use.

All the concepts within the three Ecosystem Canvasses were considered and their relation to health and to the South African context determined. As a result, a Venn diagram was constructed to illustrate

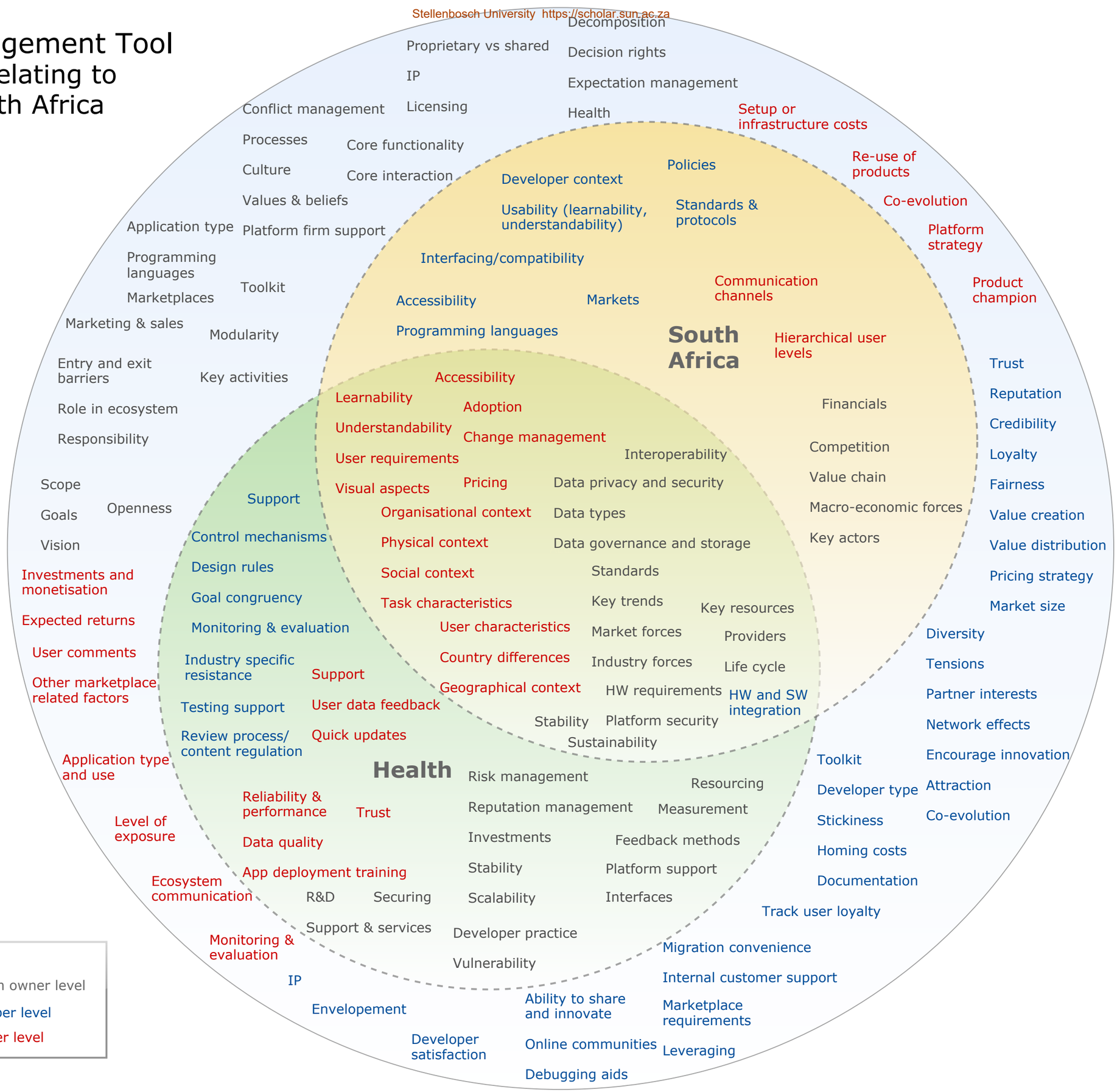
these relations and is included after the complete framework at the end of this chapter. This diagram, shown in Figure 107, comprises all concepts included in the three Ecosystem Canvasses. The concepts are grouped according to four categories: (1) a priority for health (green circle), (2) a priority for the South African context (yellow circle), (3) a priority for both (overlapping section) or (4) not being a priority for either of these context (larger blue circle). The concepts are also colour-coded based on their relation to the ecosystem levels. The grey concepts derived from the platform owner level of the framework, the blue concepts from the developer level and the red concepts from the end-user level. The categorisation, however, was not explicitly validated, but was constructed as a result of the insights from the evaluation process.

The overlapping section of the diagram provides the concepts that are high priority in both the South African and health contexts. Linking with the data from the semi-structured interviews in Section 7.2.4, where the concept mentions were ranked in Figures 73, 74 and 75, data privacy, security, governance and storage are crucial. Understanding the complete context of the end user and subsequently designing accordingly is also important. The specific country and geographical implications on the design, development and deployment should be carefully investigated. Accessibility of the application should be ensured prior to deployment and partnered with sustainable adoption and change management strategies. Particularly within the SA health context, users will most likely abandon the application if it is not properly integrated into their current lifestyle or business processes. As technology evolves rapidly, it is also important that the trends, market and industry be monitored for disruptions and advances.

9.7 Chapter 9 conclusion

Chapter 9 presented the final framework and management tool. A concise background and motivation of the framework were given. The framework was evaluated against predetermined criteria as well as its initial aims. The final management tool comprises six canvasses. Each of these canvasses was discussed in detail. The application of the framework and relation of the concepts within the framework to the South African health context was also included. Following the final management tool, the concluding chapter is presented next.

Platform Management Tool
All concepts - relating to health and South Africa



Key:

Platform owner level

Developer level

End-user level

Platform Management Tool
Pre-use Canvas

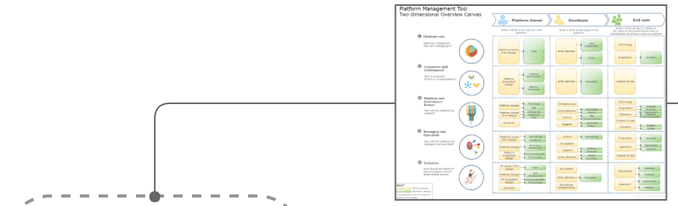
Establish Platform Profile

Determines perspective and approach towards tool

	Profile consideration	Directing question	Implication(s)
1	Platform Type	Is the platform a transaction platform, an innovation platform or an integrated platform?	This factor will lead to one of the following three cases: (1) Concepts relating to economic view emphasised (2) Concepts relating to engineering view emphasised (3) Concepts relating to both views emphasised
2	Internal or External Platform	Does the platform owner firm function as an internal or external platform firm?	This decision will lead to one of the following two cases: (1) An internal platform will approach ecosystem canvasses with the platform and developers as the same firm (2) An external platform will approach ecosystem canvasses with the platform and developers as separate firms
3	Platform Distribution Channels	How will the platform and end-products be distributed or accessed?	These decisions will emphasise certain concepts and categories. For example: cloud-based, online or offline access or distribution via a marketplace will affect platform design
4	Application Industry	In which industries will the platform or its end products, services or technologies be used?	Certain industries (e.g. health) will require special attention to certain categories and concepts. For example concepts relating to standards, protocols, control mechanisms, context of use, etc.

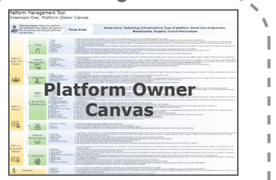
Tool Overview

Graphical overview of canvasses included in tool



Overview Canvas:

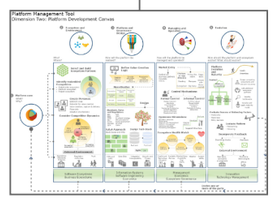
Links two dimensions



Dimension One: Ecosystem actors

Canvasses' aims:

- Highlight key concepts for consideration
- Ask key questions regarding concepts
- Categorise concepts



Dimension Two: Platform development

Canvas aims:

- Outlines development categories
- Presents possible interpretations of Ecosystem Canvasses' concepts (tools, methods, etc.)
- Links categories to SA health

Platform Management Tool
Two-dimensional Overview Canvas

	Platform owner	Developer	End user
	When I think of my own firm and platform	When I think of the users of my platform	When I think of the (1) clients or (2) users of end products/services or technologies developed using my platform
1 Platform core What am I designing? Why am I designing it?	Platform Owner Firm Design Vision	Entry Barriers Value Configuration Mission	Technology Proposition Evolution
2 Ecosystem and Environment Who is involved? Where is it implemented?	Platform Ecosystem Design External Environment Platform Ecosystem	Entry Barriers Ecosystem	Context of Use
3 Platform and Governance Design How will the platform be realised?	Platform Design Tech Infrastructure R&R Platform Owner Firm Design Internal Org Operations Vision Evolution	Technology Infrastructure Entry Barriers Technology Mission Control R&R Performance Support Community Platform	Technology Proposition Financial Evolution Operation Deployment Feedback Privacy/security Context of use Interface Usability Design
4 Managing and Operation How will the platform be managed and operated?	Platform Owner Firm Design Internal Org Operations Platform Design Technology Infrastructure Platform Ecosystem Design Ext Environment PF Ecosystem	Control Performance Ecosystem Support Platform Community Entry Barriers Mission Ecosystem	Proposition Operation Operation Deployment Feedback Context of Use
5 Evolution How should the platform and ecosystem evolve? What should evolve?	PF Owner Firm Design Vision Platform Design Technology Infrastructure PF Ecosystem Design Ext Environment PF Ecosystem Evolution	Ecosystem Entry Barriers Ecosystem Technology Infrastructure	Proposition Operation Evolution Operation Deployment Feedback

Key*
- Primary category
- Secondary category

* only applicable for Overview Canvas and Dimension One canvasses

Platform Management Tool
Dimension One: Platform Owner Canvas

Platform Owner: Owns the platform and platform firm, builds and governs the ecosystem and designs platform architecture.

Focus Areas

Governance; Technology Infrastructure; Type of Platform; Novel Core Interaction; Monetisation; Support; Control Mechanisms

Platform Owner Firm Design	Vision	1. Scope 2. Goals 3. Vision 4. Measurement 5. Core functionality 6. Core interaction 7. Stability 8. Openness 9. Financials	1. What is the area(s) of platform operation? How will scope creep and the crossing of predetermined platform boundaries be prevented? 2. What are the main goals of the platform and the platform owner firm? How will these goals relate to users of the platform? 3. What is the envisioned future state of the platform, platform owner firm and ecosystem? Does the vision attract the desired participants to the platform and ecosystem? Should the vision be shared by all participants within the ecosystem? 4. What KPIs can be applied to the platform? How will the current state of the platform be measured relative to the envisioned future state? How will continuous improvement be implemented? How will success be measured in terms of platform owner firm, developers and end users? 5. What is the main function that the platform aims to implement or achieve? What types of additional functionality could be added in future? What is the main purpose of the platform? What gap in the market does it aim to fill? 6. What interaction(s) will be facilitated by the use of the platform? Who will innovate on top of the platform? This links to the main source of value exchange and creation on the platform 7. Does the company vision, mission and strategy give a sense of stability within the platform owner firm? Will external parties perceive the platform as stable, due to its association with the platform owner firm? 8. Does the platform owner firm adopt a sense of transparency? In terms of strategy, governance, etc. 9. How can the platform be sustainably funded? How will the platform create, capture and deliver value? To what extent will the platform owner and developers share revenue?
	Internal Organisation	1. Key resources 2. Conflict management 3. Processes 4. Culture 5. Values and beliefs 6. Platform firm support	1. Who are the key human resources needed to implement the core functionality (programmers, IT specialists, health specialists, doctors)? What/who are the key resources needed to realise the platform? Refers to personnel, infrastructure, access, technology, etc. 2. What are possible tensions and areas of conflict that may arise within the ecosystem? How will each of these be managed? There are inherent tensions within the ecosystem, if it escalates, it can harm the ecosystem, trust and sustainability 3. What are the required internal processes for optimal platform functioning? These may include separate firm-level meetings, or ecosystem meetings. Are common organisational processes such as new product development, customer service, relationship management, etc., required within the platform owner firm? What plans and procedures can be put in place within the organisation to manage conflict/tensions/innovation? 4. Will the firm create a culture of debate and discussion? Does the company culture aim to deal with conflicts in a healthy manner? Does the company culture encourage innovation? 5. Are there particular values and beliefs that the platform owner firm adopts? Should ecosystem participants adopt and share in these values and beliefs? 6. Who are providing the internal support, especially in the case of an internal platform?
	Operations	1. Research and development 2. Support and services 3. Marketing and sales 4. Risk management 5. Reputation management 6. Investments	1. Will the R&D be done in correspondence with developers? How will the platform owner firm ensure that the evolution of the platform aligns with the rate of emergence of new technologies and innovations? Will R&D be outsourced as a part of an open innovation approach? 2. Is there an adequate, rapid-response, support structure for users of the platform? Will there be support available for new platform users? 3. What strategies can be adopted to encourage platform ecosystem growth? How will network effects be initiated? 4. What are possible risks associated with the core functionality and interaction? What are possible risks associated with the ecosystem participants? How will potential emerging risks (such as the need to evolve, or envelopment, or expansion of scope, or monetary risks) be monitored? Can risks be shared between ecosystem partners? What are risks related to that specific industry, partners or technology? 5. What can be done to improve the image of the platform owner firm and platform? How do others perceive the platform firm? 6. Will profits be re-invested into the platform and ecosystem? Can this encourage innovation from complements, or attract developers to the platform?
Platform Design	Technology Infrastructure	1. Stability 2. Scalability 3. Modularity 4. Interfaces 5. Interoperability 6. Toolkit 7. Openness 8. Feedback methods 9. Application type 10. Programming languages 11. Marketplaces/ distribution channels 12. Data privacy and security 13. Data types 14. Data governance and storage 15. Security 16. Key activities 17. Providers 18. Platform security 19. Platform support 20. Hardware requirements	1. Can developers continue as normal if alterations to the core platform are made? Are the interfaces stable? What measures can be undertaken to facilitate stability of the platform? 2. Can the platform function equally well with minimal users as with a large demand? How can the platform use or leverage its ecosystem for scalability and adaptability? What measures can be taken to enable/facilitate scalability? 3. Is the platform technological infrastructure developed in such a way that it enables developers to innovate and create their own products and services without affecting the platform owner firm, other developers or end users? What does the tech stack look like? What are different levels of infrastructure (building blocks)? 4. What will the interfaces comprise? What APIs or standard interface protocols will be used/can be used? 5. What standards, protocols or policies should the platform align with or be able to interface and interoperate with, in order to implement the core interaction and functionality? 6. What toolkit will be provided to external parties to enable innovation on the platform? Will such a toolkit aid in developer loyalty, platform adoption and level of innovation? 7. To what extent will external parties be able to access the different layers of the platform and change functionality for their own purposes? Is this level of openness enough to facilitate and encourage innovation? What does this mean for the software platform design? 8. Will there be a method of obtaining feedback from developers and end users of the platform? Will this be beneficial in a continuous improvement approach? Does the possible benefits of implementing this feedback loop outweigh the cost of implementation? 9. Is the desired extension/application a mobile, web-based or hybrid app? How does this affect the software platform design? 10. What programming language will the platform adopt? What is the effect of the programming language on developer attractiveness? 11. How will the products developed on the platform be distributed? Will the end-products of the platform be distributed via a marketplace? Should provisions be made within the software platform to enable this distribution? 12. What type of data will be transferred and stored during the use of the platform? Are there specific data security and privacy measures that should be taken? 13. Will specific data types be used? The data types may be industry related (specifically in HC) 14. How and where will the data generated be stored? Who has ownership of the different types of data generated by the use of the platform? Can aggregated data be used by developers to strengthen their competitive position? 15. What are the security measures taken to secure its users, the platform owner firm and all transactions and data generated by the platform? 16. What are the key activities required to achieve the core interaction and functionality of the platform? Includes technology, connectivity, IP, storage, etc. 17. What technologies will be used to implement the platform? In terms of HW and SW or other embedded platforms? How will this influence the software developed or integration requirements?' 18. What security precautions will be implemented to protect the platform against external factors such as bad developer practices? 19. Will there be support for the use of the platform? Who will provide this support? Will it be integrated into the software? 20. What are the hardware requirements to realise the platform? This may refer to servers, back-ups, etc.
	Rules and Regulations	1. Proprietary vs shared 2. Intellectual Property 3. Licencing 4. Standards	1. What is the ownership structure of the platform and its components? 2. How can the IP rights be established to facilitate third party innovation and not limit it? 3. What will the licencing agreements, if any, between the platform owner firm and developers look like? 4. What IT standards should the platform and interfaces adhere to? Are there specific ISO, IEEE or governmental standards that are related to the core interaction and functionality?
Platform Ecosystem Design	External Environment	1. Key trends 2. Market forces 3. Industry forces 4. Competition 5. Value chain 6. Macroeconomic forces	1. What industry trends exist that may influence the platform? What are the emerging technologies currently disrupting the industry? What are other possible disruptive technologies that may influence the platform and its adoption? What is the cultural and natural setting into which the platform is being introduced? Will the culture or society have an impact on the platform adoption? (Africa). For example an increase in mobile phone uptake, individualism, millennial generation, new health policies, blockchain, crowd-funding, crowd-sourcing, etc. 2. Who is the target market and what are major identifying characteristics? What are customer needs that are typically unsatisfied? 3. Who are the competing ecosystems? What differentiates this platform and ecosystem? Why would parties choose this platform and ecosystem? 4. Who are the main competing platforms? Are there substitute products/services to the platform? 5. Who are the upstream and downstream stakeholders or actors that are relied upon? 6. What does the effect of economic growth have on the adoption of the platform? What are current global, national and local economic trends that may affect the adoption of platforms?
	Ecosystem	1. Key actors 2. Entry barriers 3. Role in ecosystem 4. Responsibility 5. Technical and socio-organisational barriers 6. Decomposition 7. Decision rights 8. Ecosystem health 9. Expectation management	1. Who are the envisioned key actors within the ecosystem (this will relate to the scope and core proposition)? How will these key actors be encouraged to join the ecosystem? Why are these key actors needed within the ecosystem (niche creation, diversity)? 2. What are the major entry barriers that external developers may encounter in joining this platform ecosystem? Are the ecosystem entry barriers too high (thereby reducing new entrants and innovation) or too low (reducing quality)? How can a sense of control be applied through establishing entry barriers? 3. What role does the platform owner firm aspire to adopt in the ecosystem (keystone, dominator)? Is the platform firm leaning towards a dominator strategy and is this affecting the ecosystem health? What actions can be taken to establish the desired role within the ecosystem? 4. What are the different responsibilities between ecosystem participants? How will all participants be made aware of these responsibilities? Will this responsibility be seen as an entry barrier to joining the ecosystem? 5. Are there any technological barriers between the different actors within the ecosystem that should be noted? Will communication and collaboration be possible in projects that are geographically distributed? 6. What is the envisioned organisational structure within the ecosystem? How can the ecosystem be divided into subsystems? 7. Who will have the main authority in the ecosystem? To what extent will other participants have rights and authority to decision-making? 8. How can the health of the ecosystem be monitored and evaluated? What are the key relationships or components required to maintain ecosystem health? How is ecosystem health defined? 9. What are the expectations of the different ecosystem actors? How will these expectations be managed?
Evolution		1. Resourcing 2. Securing 3. Sustainability 4. Life cycle	1. How will new resources, knowledge, functionalities and capabilities within the platform ecosystem be enabled and encouraged? 2. Are there new security measures to be implemented with additional functionalities? Should the level of control exerted by the platform owner firm be modified? Is the control portfolio efficient and effective? 3. Is the platform firm as well as the platform designed for sustainability? Will the platform need to evolve to align with mandatory core-specific organisations/initiatives? Is the revenue model designed in such as way to ensure survival at each stage of the technology life-cycle? 4. At what stage of its life cycle is the platform and platform firm at? How do this affect the managerial and design focus of the platform and firm?

Platform Management Tool
Dimension One: Developer Canvas

Developer: Develops extensions, modules such as apps using the platform. Can be external or internal to the firm.

Focus Areas

Entry Barriers; Ability to Innovate; Boundary Resources; Openness; Feedback

Entry Barriers

Technology

1. Openness
2. Accessibility
3. Programming languages
4. Toolkit
5. Developer type
6. Stickiness
7. Homing costs
8. Documentation
9. Standards and protocols
10. Support
11. Usability
12. Developer satisfaction
13. Developer context

1. Will the level of architectural openness limit the developers to develop their own products and services? Is the level of openness a potential threat to the platform architecture in terms of duplication or theft?
2. How will developers access the platform?
3. Will the programming language required to develop products and services be difficult to learn? In the case of a non-popular programming language, why will the platform benefit by using it?
4. What features should be included in a toolkit to ensure quality and ease of use of the platform? From a developer's perspective, what are the requirements of a toolkit to enable complementary products and services to be developed on the platform?
5. What would a typical developer aim to achieve on the platform? What type of app would developers develop (enterprise, commercial, personal, web-based, hybrid, native apps)? Further extensions, modules, added functionality?
6. How difficult will it be for a developer to leave the platform (lock-in)? Will this have an effect on a developer's motivation to join this platform?
7. What are the complete set of costs associated with joining the platform? Will access to the platform and its interfaces be restricted based on costs (different packages)?
8. Are there sufficient documentation available to describe the comprehensive use and functionalities of the platform?
9. Does the platform use and follow well-known and industry accepted standards and protocols?
10. Does the platform provide internal and external support? Internal refers to platform owner firm's dedicated support team and external refers to communities outside of the platform firm
11. How usable is the platform from a developer's perspective? Usability can refer to learnability, understandability, etc.
12. Can the satisfaction of developers be measured? Is it enjoyable to develop complementary products and services on the platform?
13. What is the context of use of the envisaged developers? Do they have access to the latest technologies, laptops, connectivity or resources?

Mission

1. Trust
2. Reputation
3. Credibility
4. Loyalty
5. Fairness

1. How can trust be fostered within the ecosystem? Is the platform conveying a sense of trust (not constantly enveloping)? Is there a sense of trust between (1) platform owner firm and developers, (2) platform owner firm and end users, (3) developers and end users?
2. How do external parties perceive the platform, the platform ecosystem and the platform owner firm? Is this a desirable view?
3. Do the platform and platform owner firm do what they set out to do? Is the platform brand and reputation credible?
4. How can the platform owner firm invest to maintain the loyalty of developers? What are rival ecosystems doing to attract developers?
5. Are the dealings within the ecosystem fair (referring to monetary and proprietary aspects)?

Value Configuration

1. Value creation
2. Value distribution
3. Pricing strategy

1. How will developers create and share value within the platform ecosystem? What are ways in which value can be co-created? Can the developers create adequate value to motivate joining the ecosystem?
2. How will value (profits) be divided and distributed throughout the ecosystem?
3. What is the revenue model and will it be beneficial for complementors? Such as pay fixed amount, percentage, subscription, licencing fees, etc.

Ecosystem

1. Market size
2. Markets
3. Envelopment
4. Diversity
5. Industry specific resistance

1. What are the global footprints of the platform and its ecosystem? What is the potential market that a developer will be able to access when joining the ecosystem?
2. Will the end-products or services be distributed via an application portal/marketplace? Will developers be able to distribute freely on these portals if using the platform?
3. How and when will new functionalities be incorporated into the platform? How will developers be encouraged to join the ecosystem if the platform regularly adds functionalities which might envelope a developer?
4. Are there a healthy variety of developers using the platform? Will this encourage developers to join and share value, or result in unhealthy competition within the platform ecosystem?
5. Are there industry-specific barriers to adoption? For example medical doctors concerned about legal implications when joining a tele-health platform

Ecosystem

1. Tensions
2. Partner interests
3. Network effects
4. Encourage innovation
5. Co-evolution
6. Attraction

1. Could risks taken by the platform owner firm (regarding evolution, financial, scope boundaries) affect the complete ecosystem and thereby result in tensions between ecosystem participants? Relate to risk management and how it is shared by all parties in ecosystem
2. Does the platform owner firm take the best interests of the both themselves and developers into account when making decisions? Does the platform owner firm act in a selfish way at the cost of other ecosystem actors?
3. How will network effects be encouraged amongst developers? Are there any sign of negative network effects within the ecosystem? How do the ecosystem size and scope affect the prevalence of network effects?
4. How can innovation be shared with developers? How can innovation from developers be encouraged? Will external innovation lead to less risk and improved R&D?
5. Is the platform co-evolving with the complete ecosystem? Should ecosystem goals, vision and current markets be re-evaluated?
6. How will planned and potential groups of actors be attracted to join the ecosystem?

Technology Infrastructure

1. Interfacing/compatibility
2. Feedback
3. HW and SW integration
4. Marketplace requirements
5. Leveraging
6. Developer practice
7. Vulnerability

1. To what extent will compatibility with other platforms or systems be enabled or allowed? What level of control will be maintained with regard to interfacing of developer products and services with other systems, solutions or components?
2. Is there a method of obtaining feedback from developers regarding the platform architecture, interfaces, support, etc.? Will developers be encouraged to provide feedback regarding the platform?
3. Do the hardware devices on which the platform and its end-products will be used have an effect on the platform design? Should the platform be able to integrate with existing software systems or components in order to fulfil its function? Should specific data formats or protocols be accommodated?
4. How can the platform owner firm design its platform to enable developers to deliver better apps at their preferred marketplaces? What are the specific marketplace requirements?
5. How can the developers be leveraged to enable scalability and adaptability of the platform and the ecosystem? Are there developer functionalities that can be used by the platform?
6. Is developer training required to use the platform? How will developer best practices be encouraged and enforced if necessary?
7. What could be possible weak points in the platform software that could endanger the platform? Could developer laziness compromise platform security?

Control

Rules and Regulations

1. Policies
2. Intellectual Property
3. Data privacy and security
4. Data governance

1. Are there any current governmental or organisational policies that the platform owner firm and developers should be aware of?
2. How can the platform owner firm help developers protect their own IP?
3. Should the personal data of developers be protected from the platform owner firm and from other developers? Can developers be assured of the safety of their data?
4. Who owns the data generated by the developers' products and services? Could data ownership lead to information asymmetry?

Performance (Formal and Informal)

1. Control mechanisms
2. Design rules
3. Goal congruency
4. Monitoring and evaluation
5. Track user loyalty
6. Review process/content regulation

1. What control mechanisms could be implemented to encourage desirable behaviours in developers? Content regulation, review processes, documentation, design guidelines etc.
2. What are the fundamental rules that developers should obey when using the platform? Are these design rules stable and consistent? Do they avoid favouritism amongst developers? Are these design rules versatile enough to allow for developer innovation?
3. Are the goals of developers and the platform compatible (to reduce the possibility of future tensions and competition)? Could aligned goals lead to increased productivity and innovation?
4. How can the ecosystem and its participants be monitored and their performance evaluated? How can M&E be used in managerial decision-making processes?
5. Is the number of active developers increasing or decreasing? Is there an external competing ecosystem causing users and developers to migrate?
6. Will the complementary products/services be reviewed by the platform owner firm as a method of quality control? Who will be reviewing these components? Are the developers aware of this reviewing process? What are the conditions to be met to "pass the test"?

Support

Community Support

1. Online communities
2. Ability to share and innovate

1. How can connectedness and a sense of community between developers in the ecosystem be encouraged and facilitated? Can developers learn from each other and build on top of each other's products and services?
2. Is there a method of sharing knowledge within the ecosystem? How can innovation be encouraged amongst developers?

Platform Support

1. Migration convenience
2. Internal customer support
3. Design guidelines
4. Debugging aids
5. Testing support

1. How can the migration convenience from a competing ecosystem be supported? How can the platform owner firm add to the convenience when joining from a different ecosystem?
2. Is there a dedicated team within the platform owner firm to supply the required support for users of the platform?
3. Can the platform firm and developers learn from major development tools and user interface guidelines (such as Apple HIG and Android UI guidelines)? Are there existing software frameworks that developers can use? What existing platforms can the developers interface with?
4. Will debugging aids be developed and be a part of the toolkit provided to developers?
5. Which forms of testing support could be supplied to developers?

Platform Management Tool
Dimension One: End-user Canvas

End user: (1) client acting as an intermediary, or (2) end users of products, services and/or technologies developed using the platform

Focus Areas

(1) Pricing; Value Creation; Product Specifications

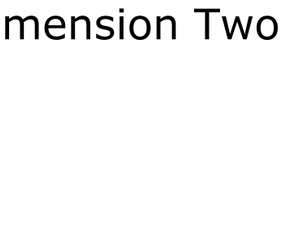
(2) Usability; Competition; Satisfaction; Feedback

Key:
- Clients
- App end-users

Technology		1. Application type and use 2. Data governance 3. Rules, regulations and standards 4. Interoperability 5. Intellectual Property	1. What type of application does the client want? Who are the intended user and the subsequent functionalities of this application? What data will be generated? 2. Who will own the data? Who has access to the data? 3. What are the rules, regulations and standards to be considered within the client's business or industry? 4. Are there existing client systems or technologies that the application should interoperate with? 5. What will the IP rights with regards to the application be?
Proposition	Financial	1. Value creation and distribution 2. Investments and monetisation 3. Expected returns	1. How will value be created and fairly distributed between the client and platform owner firm? 2. What are the required initial investments? What is the pricing strategy for the application? 3. What are the expected results and returns from the client's side? Important to ensure expectation management
	Operation	1. Feedback 2. Ecosystem communication 3. Monitoring and evaluation	1. How will client feedback be enabled? What are the desired types of feedback that the client desires within the application? 2. Are there sufficient communication channels between: (1) the end users and clients and (2) clients and platform owner firm? 3. Are there specific components that should be monitored and evaluated on behalf of the client?
	Evolution	1. Sustainability 2. Vision 3. Co-evolution 4. Re-use of products 5. Platform strategy	1. How can the sustainability of the project be ensured? Referring to technology, financial, business and user-adoption and use 2. What are the vision and goals of the project? Are these shared between the platform owner firm and client? 3. Will the project evolve? How will the co-evolution between client, platform, platform owner firm and applications be facilitated? 4. Can components of the project be used for another project or to improve another application? 5. Does the client align with the platform strategy? In other words, is the client a "good move" in terms of the platform and platform owner firm's vision?
Context of Use		1. Organisational context 2. Physical context 3. Social context 4. Task characteristics 5. User characteristics 6. Country differences 7. Geographical context 8. Accessibility 9. Hierarchical user levels	1. What is the organisational context in which the end-product or service will function? What rules and regulations (such as safety) should be noted and not violated when using the app? 2. What are the physical working conditions of the end user? Are there possible noise, particular ambient conditions or health and safety issues that would influence usability? 3. What is the social context in which the end-product or service will be used? Will assistance in using the product or service be available? Is the product or service for single or multiple users? 4. What are the specific characteristics of the task to be performed? Frequency of use, duration of use, physical and mental demands, app complexity 5. What are the particular end-user characteristics? What languages should be available? What level of computer/digital literacy do end users have? Is the user fully literate? Health aspects such as dementia, ADD, deaf, colourblind, etc. should be noted in app design. 6. Does the country in which the app is being deployed have specific content, data, freedom of speech, etc. requirements? Are there specific features that would increase adoption in a specific country? 7. In what geographical context will the app be required to operate? Does this have an effect on the available network coverage? Will the network coverage affect the functioning of the app? 8. How will end users access the products, services or technologies? Are there any barriers hindering access? 9. Are there different app-user managerial levels? How do their needs differ? Does this require additional training or deployment activities?
Operation	Deployment	1. Setup or infrastructure costs 2. Adoption 3. Change management 4. Reliability and performance 5. Data quality 6. App deployment training 7. Support 8. Communication channels 9. Trust 10. Product champion	1. Are there any additional infrastructure required to deploy the applications? Are there setup costs associated with this infrastructure? 2. How can adoption of the applications be facilitated and sustained? 3. How can the effect of the change brought by application use, be reduced? What job responsibilities and work protocols are changing through the use of the app? 4. Are the software and the corresponding infrastructure reliable? How can the performance of the app be measured? How does this reflect on the back-end platform? 5. Is the quality of data adequate for its desired purpose and possible further use? Specifically in healthcare, structured or unstructured data may be required 6. Does the app require specific deployment activities? Specifically in enterprise apps, such as within mines, factories or hospitals, training may be required 7. Is there support readily available for the end-users? Support can be in-app support or within the developer or platform owner firm 8. Are there sufficient communication channels between end-user managerial levels, end users and clients and with the platform owner firm? 9. Is there a sense of trust from the end users? How does this influence adoption and network effects? 10. Is there an end user that can lead deployment and act as the main line of communication?
	Feedback	1. User data feedback 2. Quick updates	1. What feedback data can be obtained from the end user? Can this data be used to improve the app or the platform? Possibility of mining marketplace data, surveys, incorporate activity logs, controlled-environment experiments, etc. 2. Can updates be implemented rapidly? New versions may be required to run on specific operating systems
	Privacy and Security	1. Laws and regulations 2. Data privacy and security 3. Data governance	1. What are the possible laws and regulations related to the industry in which the app operates? 2. How will the privacy and security of the end users be ensured? 3. How will the end-user data be stored? Who within the ecosystem have access to what data? Will developers share data within the ecosystem?
Interface	Usability	1. Learnability 2. Understandability 3. User requirements	1. Can the app easily be learnt? Does it require dexterity? Can the app easily be used to its fullest extent without a large learning time required? 2. Is the navigation through the app logical? Are there confusing elements such as buttons or layouts? 3. What are the specific end-user needs and requirements to enable usability of the app?
	Design	1. Visual aspects 2. Level of exposure 3. Pricing 4. User comments 5. Other marketplace-related factors	1. What will the app icon look like? What will be the visual layout of the app interface entail? Will this be a selling point of the app and encourage adoption? What is the envisaged user experience? How can the use of colours and fonts aid in the best possible user experience? 2. How popular is the app or the platform amongst the end users? Has the app been successfully implemented in other countries, industries? Popularity has an effect on further adoption 3. How does the end-user target-market influence the pricing of the app? Will the platform owner provide guidelines regarding app pricing? What will the cost of access to the app be? 4. Is there an option for end users to give feedback on the app? Specifically regarding crashes, speed, difficulty of use, unnecessary features, etc. 5. Should the app comply with specific marketplace requirements? Apple for example removing apps not built on 64-bit architecture

Platform Management Tool
Dimension Two: Platform Development Canvas

1 Platform core
What?
Why?



2 Ecosystem and Environment

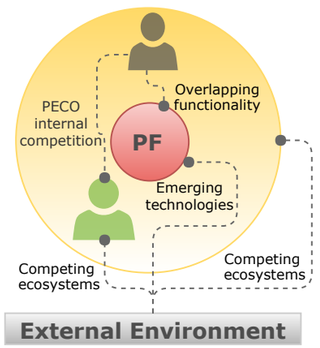
Who?
Where?

Select and Build Ecosystem Partners

Identify Embedded Ecosystems
- Stakeholder ecosystem
- Platform ecosystem
- Project ecosystem

Create Personas
Establish roles
Potential for value creation
Value creation, capture & delivery
Financials
Adoption mechanisms

Consider Competitive Dynamics



External Environment

Regulations Standards Protocols
Regulatory Authorities
Trust

3 Platform and Governance Design

How will the platform be realised?

Define Value Creation Logic

Establish platform offering → Consider ecosystem value contributors → Monetisation (Value capture and distribution)

Monetisation

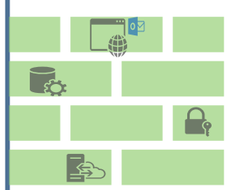
Subscription	Project scope related	Transaction fee
Percentage profit	Credits	Access - enhanced
Per user	Outsourcing	Customer base
Per feature	Sponsorship	Licensing

Design

Standards, Rules and Regulations

ISO	PoPI
IEEE	HISP
SANS	SA eHealth strategy
HL7	PPD principles for digital development
ICD10	SA HNSF
SNOMED	HIPAA
SITA	

S.O.A Approach
Black boxes and APIs



Design Tech-Stack

Agile ON

EHRs and EMRs
Data Silos
Integration Interoperabilty
Security and Privacy

4 Managing and Operation

How will the platform be managed and operated?

Market Entry

Medical aid
Business partners
Hospitals
Clinics

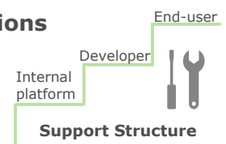
Chicken-or-egg dilemma	Follow-the-rabbit	Piggy-back
Seeding	Marquee	Single-side
Evangelism	Big-bang	Micro-market

Control Mechanisms

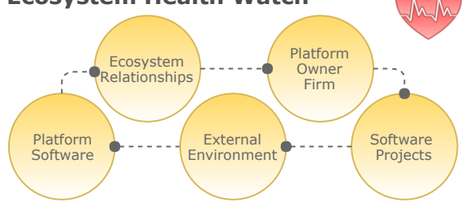
Formal Control
Design rules and standards
Documentation
Penalties
Monitoring & evaluation
Content regulation
Review processes
Development aids

Informal Control
Common values
Shared beliefs
Community building
Methods of guiding behaviours

Openness Dimensions
Boundary resources
Governance
Research and development
Platform management
Marketing and sales
Consulting and support



Ecosystem Health Watch



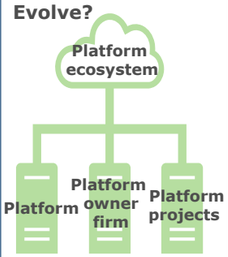
Health and Technology Education
Available Devices
(Mobile) Data: Availability Cost Traffic
Adoption
Sustain-ability

5 Evolution

How should the platform and ecosystem evolve? What should evolve?

Platform Evolution and Maturity

Evolve?



Screen competing ecosystems and relevant industries
Add additional ecosystem partners
Identify bottlenecks
Develop and apply maturity model

Evaluate Success of Balancing Factors
- Modularity
- Openness
- Entry barriers

Evaluate Platform
- Resourcing
- Securing

Incorporate Feedback

Stumbling blocks
Feedback

External Environment

New laws, standards or protocols
Emerging technologies

Software Ecosystems
Business Ecosystems

Information Systems
Software Engineering
Economics

Management
Economics
Ecosystem Governance

Innovation
Technology Management

Evolve one or more of the parts

Chapter 10: Conclusions and future work

Chapter 10 key objectives:

- Provide a summary of the study by discussing each of the four project parts
- Show how the research aims and objectives were met
- Elaborate on the research contribution
- Discuss the limitations of this study
- Provide recommendations and future areas to investigate

10.1 Introduction

The concluding chapter presents the research findings and discusses how each of the research objectives was met. The context of this chapter within the Research Design is shown in Figure 108. The discussion includes elaborating on the four parts of the Research Design from Chapter 2. The impact of the study is also discussed and its limitations given. The chapter concludes with recommendations and further avenues for exploration.

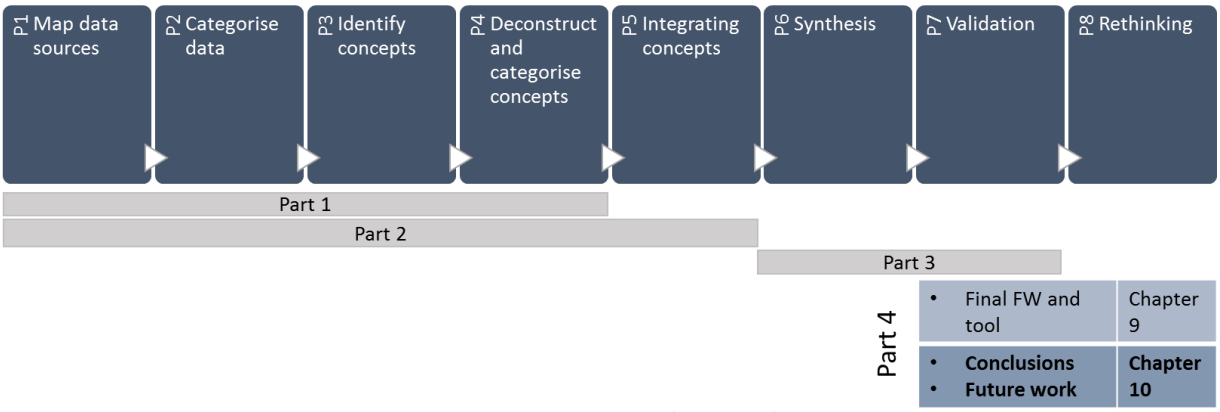


Figure 108: Document context diagram: Chapter 10

10.2 Research summary

The project was conducted in four parts as discussed in the Research Design in Section 2.9. The summary and overview of findings are discussed. Sections 10.2.1 to 10.2.4 each commence with a diagram that gives an overview of the components that made up that Part.

10.2.1 Part 1: Research aims and making sense of the literature

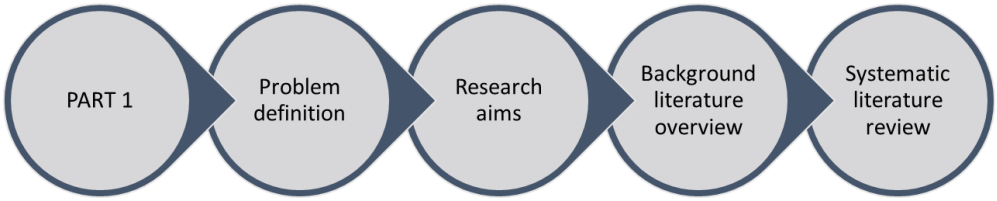


Figure 109: Overview of Part one components of this study

Part one of the project included introducing the problem, the problem definition, research aims and objectives and the systematic literature review as shown in Figure 109. Chapter 1 gave an overview and motivation for the framework for the design, development and implementation of a technology

platform in the South African health context. The need for innovative health solutions in South Africa was emphasised and the possibilities enabled by technology platforms indicated. The research aim was also aligned with the Sustainable Development Goals 3 and 9 as it envisages that the increased adoption of technology platforms could result in improved health and well-being.

Subsequent to the problem definition and project motivation, the research questions and objectives were established. The project objectives were developed according to two phases. The outcome of the first phase of objectives was the inventory framework. The second phase objectives focused on evaluating, modifying and adapting the framework. The outcome of the second phase was therefore the final framework and management tool. The researcher formulated a Research Design that would enable the project objectives to be completed.

The eight-phase CFA approach developed by Jabareen [39], formed the foundation of the framework development process. The Research Design for this project was divided into four parts, each respectively aligning with the CFA process. The alignment of the four parts with the CFA process is illustrated in Figure 110. Figure 110 summarises the interpretation of the CFA process for this project and the alignment of the process to meet the project objectives.

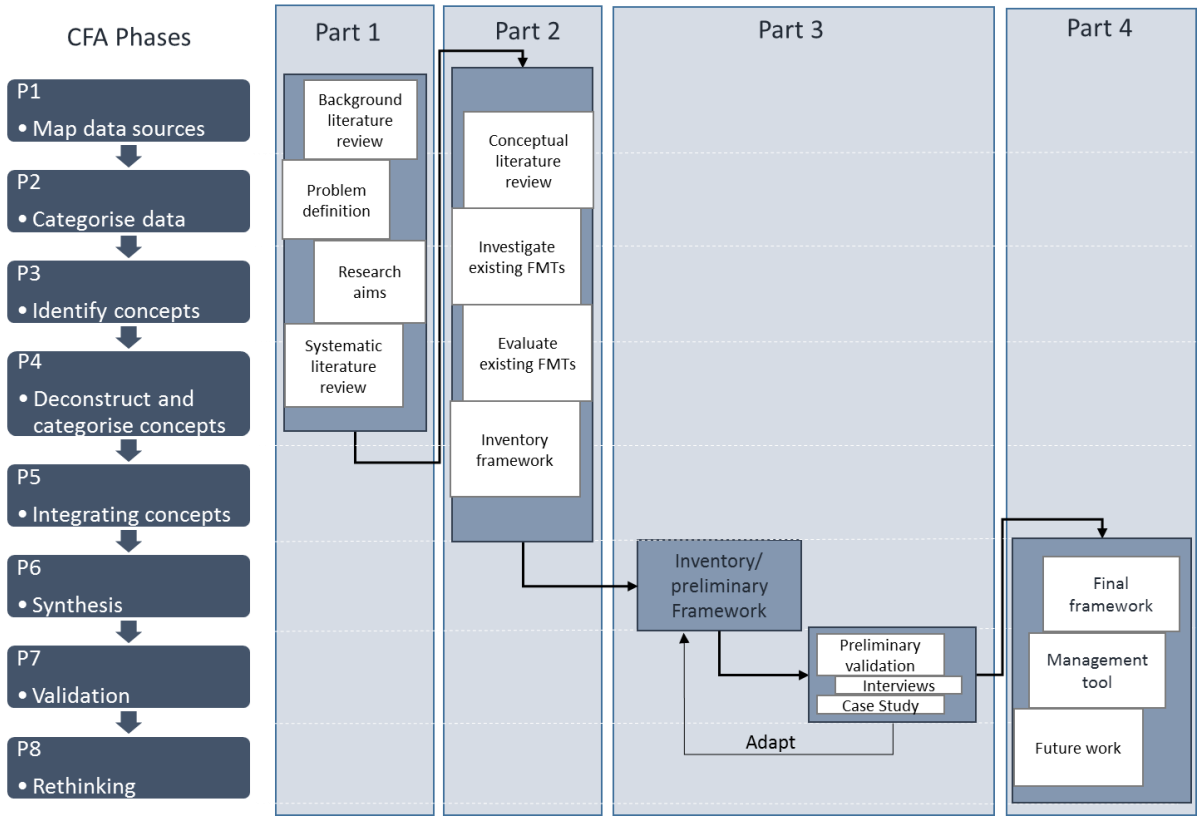


Figure 110: Reflection on the project Research Design

The systematic literature review formed a significant part of the project. The systematic review guidelines from Petticrew and Roberts [76] and Kitchenham and Charters [61] were aligned with the CFA process and followed throughout the systematic literature review process. The initial aim of the systematic literature review was to identify the key concepts related to technology platforms functioning in innovation ecosystems. The researcher developed two sets of criteria that were used to filter the initial 173 studies to arrive at the final 26 primary studies. The descriptive and conceptual data analyses resulted in six fundamental insights that would influence the remainder of the study. These insights included technology platform key concepts, the most occurring concepts, typical challenges that platform owners may face, the void of relevant research in Africa, the multidisciplinary

nature of the research, typical platform ecosystem actors and the different ecosystem definitions. The results from Part 1 of the project were used in the development of Part 2.

10.2.2 Part 2: Formulating the preliminary framework

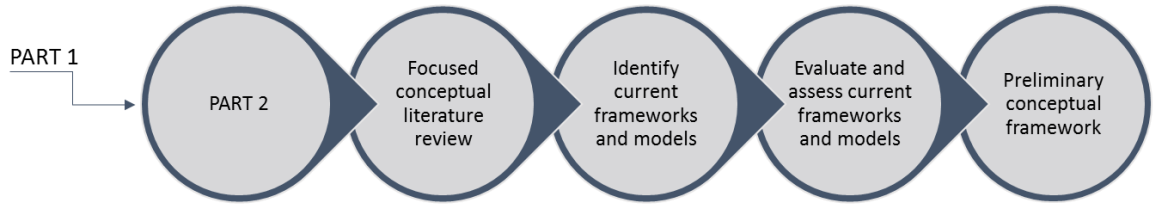


Figure 111: Overview of Part 2 components of this study

The components that comprised Part 2 are shown in Figure 111. The conceptual literature review built on the outcomes from the systematic literature review and focused on technology platforms, their ecosystems and the South African health context. The review identified the different types of ecosystems and related ecosystems to platforms. Subsequent to the relation between platforms and ecosystems, the key characteristics of technology platforms were explored. Thirteen characteristics of platforms and their subsequent ecosystems were identified and discussed. The role of the platform owner within this context proved challenging as a result of certain ecosystem dynamics and trade-offs. In order to better understand the task of a platform owner within the ecosystem, the ecosystem dynamics were explored. This included identifying the roles and context of the platform owner and its firm, the developers and the end users.

Following the identification of this challenging landscape, management tools were explored that could aid the platform owner with his task of managing the platform and governing the ecosystem. This investigation comprised analysing nine existing frameworks, models and tools. This analysis educated the researcher extensively on the advantages and disadvantages of typical FMTs available in research. It also highlighted essential framework inclusions as well as voids to address.

As a result of the outcomes of Part 1 and the abovementioned aspects of the conceptual literature review, the inventory framework was established. The inventory framework comprised three levels, namely the platform owner level, developer level and end-user level. Each of these three levels had numerous concepts that should typically be considered by a platform owner. The inventory framework was key in the framework evaluation process as it formed the inventory on which the framework-refining process was built. The inventory framework also provided an overview of the three levels and key concepts within each of these levels. Subsequent to the formulation of the inventory framework, it had to be evaluated and refined.

10.2.3 Part 3: Evaluation and adaptation of framework

The inventory framework underwent three stages of evaluation where after the final framework and management tool was established. The evaluation and adaptation of the framework formed Part 3 of the Research Design as shown in Figure 112. The empirical data obtained during the framework evaluation process contributed significantly to the refining of the framework, particularly relating to the South African health context.

The first evaluation stage comprised of relating the inventory framework to the MomConnect health platform by means of a theoretical case study. The researcher gathered and investigated all available theoretical resources on MomConnect and used this to evaluate the inventory framework. The theoretical case study highlighted voids in the framework and also provided insight into the typical

design, development and implementation of a successful technology platform in the South African health context. Subsequently, the researcher could restructure the framework to be more logical and also include additional concepts. This evaluation stage confirmed the possible use of the framework, restructured the categories within the framework and proved the framework to be relevant for a technology platform in the South African health context.

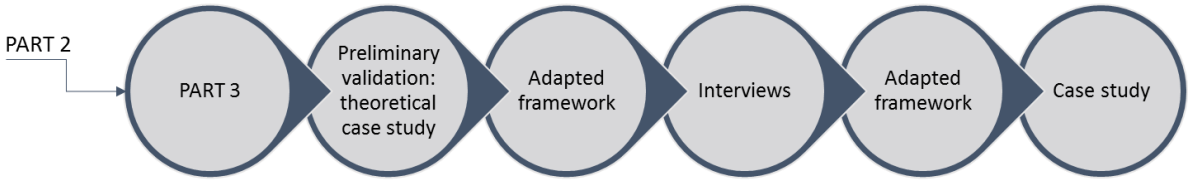


Figure 112: Overview of Part 3 components of this study

Semi-structured interviews were conducted as the second stage of the evaluation process. Nine semi-structured interviews were conducted in both international and local contexts. The interviewees included experts in innovation, ecosystem governance and health as well as platform owners and developers. The six-stage process developed by Rabionet [68], was followed for the interview process. A pivotal insight occurred during the development of the protocol for the semi-structured interviews. The formulation of the interview-guiding questions led to the birth of the second dimension of the framework. The second dimension subsequently included the five platform development parts: (1) platform core, (2) ecosystem and environment, (3) platform and governance design, (4) managing and operation and (5) evolution.

The interview data was coded by means of three cycles, each with a different outcome. The purpose of the first coding cycle was to determine whether the existing concepts included in the framework were applicable and valid in the platform and platform ecosystem context. All but four concepts could be successfully validated. The second cycle coding focused on further refinement of the data by means of adopting five lenses and identifying possible voids or disagreements within the framework. The adopted lenses included: (1) health, (2) sub-Saharan African considerations, (3) platform control, (4) support structures and (5) financing and pricing related aspects. This led to the identification of numerous additional concepts to include in the framework. The voids and disagreements were tabulated and incorporated into the framework only if the researcher thought this would add value to the framework. The third cycle coding focused on highlighting themes, patterns and deeper insights from the data. Subsequently, the researcher gained deeper insight into several concepts relating to platforms and ecosystems that could be reflected in the framework. Conceptual and structural modifications were done to the framework and added towards the usefulness and credibility of the framework.

The final evaluation stage comprised a case study on an existing technology platform firm that operates within the South African health context. The process for conducting case studies proposed by Tellis [74], was followed. The case study was designed to comprise three components, namely obtaining background information, gaining deeper insight into the firm and the confirmation of the potential usefulness of the proposed tool. The case study data was acquired through online resources, organisational notes, semi-structured interviews and discussions with Mezzanine employees. Sufficient data could be obtained to gain insight into the firm and subsequently relate this back to the framework. Both conceptual and structural modifications were applied to the framework as a result of the insights obtained during the case study. The framework could be regarded as valid and usable within the desired context. Subsequently, the final framework and management tool could be developed.

10.2.4 Part 4: Final framework and resulting management tool

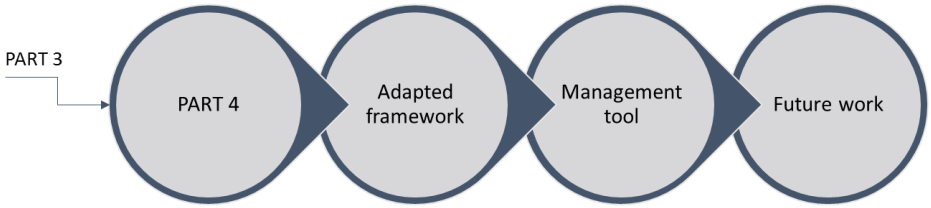


Figure 113: Overview of Part 4 components of this study

The components of the fourth and final Part of the Research Design are shown in Figure 113. The final tool could be developed and was presented in Section 9.5. The framework was initially developed only using literature, which was then followed by an iterative evaluation process. The framework is positioned within the final tool. The management tool aims to provide a useful tool for platform owners in the design, development and implementation of their technology platforms within the South African health context.

10.3 Research objectives

The overarching research objective of this study were to develop a framework that could aid in the design, development and implementation of technology platforms within the South African health context. This overarching objective was achieved by the systematic completion of eight sub-objectives. Table 62 indicates how each of these objectives were met within this study.

Table 62: Reflecting on the research objectives

Objective	Reference
RO1: Review the fundamental concepts of technology platforms from an ecosystem perspective through conducting a systematic literature review.	Chapter 3
RO2: Establish the context and requirements of technology platforms within their ecosystems and the dynamics with their ecosystem partners though conducting a conceptual literature review.	Chapter 4
RO3: Investigate and assess current frameworks, models and tools relevant to platform and ecosystem management.	Chapter 4
RO4: Deduce a preliminary framework to aid in the design, development and implementation of these platforms.	Chapters 3 - 5
RO5: Use an existing health platform in South Africa to gain understanding and modify the framework prior to evaluation in practice.	Chapter 6
RO6: Evaluate the content of the preliminary theoretical framework through interviews with experts in industry and formulate a revised framework.	Chapter 7
RO7: Test the usefulness of the framework as a management tool through a case study.	Chapter 8
RO8: Present a management tool for the design, development and implementation of technology platforms in the South African health context.	Chapter 9

10.4 Research contribution

The final framework and management tool makes contributions to research and to platform owners. The contributions will be discussed in two segments. The first segment will consider each of the tool's canvasses and their respective contributions (if applicable). The second segment will consider seven contributions of the overall framework and tool.

The first segment refer to possible contributions that could be drawn from the canvasses included in the final framework and tool and are summarised in Table 63.

Table 63: Possible research contributions of tool's canvasses

Canvas	Possible contribution(s)
Pre-use Canvas	N/A
Overview Canvas	○ Indicates the relationships between platform development parts and ecosystem actors.
Platform Owner Canvas	○ Considers not only the design of the platform itself, but also the platform owner firm and ecosystem, which forms a more holistic view. ○ Highlights and integrates challenges associated with the platform owner firm, the platform itself and the platform ecosystem. Therefore integrating management, software engineering, and ecosystem literature amongst others. ○ Provides a platform design insights to guide software development
Developer Canvas	○ Provides several entry barriers that a platform owner should be aware of in order to attract and maintain developers. ○ Highlights the importance of developer control and support structures provided by the platform owner. ○ Highlights and integrates challenges associated with developers. ○ Builds from an ecosystem perspective and integrates ecosystem related concepts into the tool.
End-user Canvas	○ Provides insights into both clients and application end users - current research typically does not consider the client, who fulfils a key role in the success of platforms in the developing country health context. ○ Highlights the importance of understanding the context of use in the South African health context.
Platform Development Canvas	○ Identifies five typical platform development parts that can be used to guide a platform owner. ○ Provides several practical methods of evolving a platform or software component. ○ Emphasises key focus areas in the South African health context. ○ Provides further research guidance by indicating the core literature for each part. ○ Can be used for both an innovation platform, as well as software products developed using an innovate platform (for example SVS is developed on Helium).

The second segment of contributions refer to seven contributions of the framework or tool as a whole. A platform owner faces challenging tasks when designing, developing and implementing his platform as described in Sections 1.2–1.4, 4.5 and 4.7. Compounding these challenges are the necessities of governance and evolution of the platform and its ecosystem. Therefore, the first contribution is that the framework was designed to be explicitly used by platform owners as a practical and usable management tool. Many frameworks in literature are informative, but not practically usable. Secondly, a user-centric focus formed a central element during the development process. The users refer to the developers and end users as well as the platform owner firm itself. This research therefore informs on the needs and characteristics of each of these ecosystem actors. The framework also aims to assist with dealing with the typical challenges that a platform owner may face. Subsequently, the platform owner can use the framework to remind and guide them through these challenges. The framework would however need to evolve continuously to remain usable.

The next contributions speak to direct gaps identified in the literature. The framework draws from both the engineering and market perspectives of platforms. This is a definite contribution of this research as there were requests for such an approach from the literature. Platforms can take on various definitions and therefore the framework addresses three types of platforms. The framework is developed to be as generalised as possible and therefore it can be used in the case of an innovation platform, a transaction platform and an integrated platform. The next gap that this research contributes to relates to technology platforms in the South African context. There is also a void in the

research on health platforms specifically operational within the South African context. Particularly in South Africa, health platforms often remain in the pilot stage. This framework highlights the need for sustainability in order to move beyond the pilot stage. Sustainability includes shared value, good leadership and governance [28]. Table 64 summarises the research contributions, motivations and references (if applicable). The references are the sources motivating for the specific contribution component of this research.

Table 64: Research contributions, motivations and references

Contribution	Motivation	Supporting references
Practical tool	Tools from literature are often not practical to use in industry.	[199], [200]
User-centric design	The framework development process included in-depth investigation of the needs and characteristics of all users (developers and end users), as well as those of the platform owner.	[35], [113] Systematic literature review
Inform on dealing with challenges	Several typical challenges were identified early on in the research and the framework developed keeping these in mind.	[3], [14]
Draws from both engineering and market perspectives	Many literature sources adopt only one of these perspectives. In actual fact, both can learn from each other.	[35], [142]
Generalised platform use	Platforms have many different definitions. The framework aims to be generalised by designing for three types of platforms.	[5]
South African context	South Africa as a developing country will require a different approach than those taken by typical literature sources from developed countries such as the USA.	[5] Systematic literature review
Health context	Platform literature specifically within the Health industry has not been researched as extensively.	Systematic literature review

A maturity model, based on this framework, has also been developed in parallel with this project. The maturity model was developed based on the Ecosystem Canvasses and can be used for continuous improvement of a platform and its ecosystem. This use of the framework indicates the value of the conceptual insights provided by the framework and highlights the potential for other uses and applications due to its informative and extensive content. Elements of the current framework can be used for other applications and for further research.

The framework developed in this study therefore contributes as a management tool for the design, development and implementation of technology platforms in the South African health context. It is envisaged that the final framework and tool would contribute towards the increased uptake of health platforms in the South African context and thereby aid in working towards SDGs 3 and 9.

The benefits of the increased adoption of health platforms move beyond the improvement of access, availability and more rapid delivery of services, but also build towards positioning South Africa favourably in order to "*create, adapt and implement novel digital health solutions within and by the public and health sectors*" [28, p. 2].

10.5 Study limitations

The researcher reflected critically on the literature reviews, the evaluation process (preliminary evaluation, semi-structured interviews, case study) and the final tool. The researcher acknowledges that there are certain limitations to this study and its findings and aspects that could have been approached in a different way:

1. The systematic literature review screening of papers was done by only one researcher and may have led to bias.
2. Only one database was used for the systematic literature review.
3. The systematic literature review resulted in identifying only 26 primary studies. The use of more databases could have resulted in more primary studies.
4. The semi-structured interviewees informed only on some of the areas related to the multidisciplinary nature of the research. Therefore more interviews with more diverse interviewees could have led to better data.
5. During the semi-structured interview data analysis, the researcher could have been biased during the coding cycles and application of the five lenses.
6. Each additional concept or modification derived from the case study on Mezzanine Ware was considered for its contribution to the final framework. If it was thought that the addition or modification would limit the framework's use to the case of Mezzanine Ware, it was not implemented or added. This selection process was done by a single researcher and could have led to bias.
7. The case study was done on an integrated platform firm. More in-depth insight into the innovation and transactional elements of the platform could have been obtained if separate case studies had been conducted for each of these types of platforms.
8. Mezzanine Ware has limited external developers. Therefore the case study could not provide in-depth insight into elements related to an external platform firm.
9. The interpretation of the evaluation process data is dependent on the author's understanding and therefore interpretation bias is possible.
10. The health and SA categorisations in Section 9.6 were not validated, but were constructed as a result of the insights from the evaluation process thus far.
11. The framework comprises many different concepts and elements which have not been investigated in depth. Therefore, future research may focus on a select few of the framework components and investigate them deeper.
12. The researcher selected the platform ecosystem to comprise the platform owner, developer and end users. As noted in Section 9.5.4.2., other stakeholders or actors may also be considered and would have an effect on the framework.
13. The framework was developed to be as generalised as possible, but platforms are diverse and complex and there will thus be platforms that would not fully relate to the tool. This tool currently focuses on integrated platforms.
14. The framework needs to evolve continuously to remain usable within the dynamic nature of technology platforms and ecosystems.

10.6 Recommendations and future work

The final management tool in Section 9.5 and the limitations from Section 10.5 highlight future research paths that can be pursued.

The first avenue for future work relates to the evaluation of the framework. Two additional case studies could be useful in refining the framework as a generalised tool. Mezzanine Ware is an integrated platform that operates mainly as an internal platform. Therefore, further case studies on both an innovation and a transactional platform could provide additional detailed information. The framework could potentially be used to formulate specific frameworks for each of the different types of platforms. It is also recommended that a case study on an external platform firm be done as certain elements in the framework could not be fully evaluated with Mezzanine Ware. Future evaluation could also include more interviews with developers and end users and thereby obtain inputs from all the users of the platform ecosystem. Particularly the End-user Canvas can benefit from and refined by conducting more case studies in the developing country health context.

As mentioned in Section 4.3, platform literature often adopts either an engineering or economic perspective. The framework aimed to incorporate both these views, but due to time limitations there are still many avenues to explore within each of these two perspectives. Therefore, future work can include further research into the engineering and economic research respectively.

The platform software design concepts included in the framework should also be investigated further. As highlighted in Section 7.2.5, these concepts within the framework are currently all seen as having an equal impact. However, certain elements are points of parity and others points of differentiation. Future work could include the rating and ranking of these design components. This could be implemented specifically from the perspectives of all users in the ecosystem.

Future work could also focus specifically on the South African health context. In Section 9.6, the researcher related all the concepts from the Ecosystem Canvases to health and South Africa respectively. The resulting diagram has not been validated and could provide the blueprint for future refinement of the framework for the South African health context.

Each of the main categories within the Ecosystem Canvasses (for example platform design, ecosystem design, control, support, interface and operation) can be researched further for a better understanding and ability to provide solutions to their respective challenges. Further investigation into ecosystem health metrics, as mentioned in Section 5.5., could also be valuable. As highlighted during the evaluation process, the control and support categories are priorities to be further investigated. Similar to a technology platform, the framework itself needs to evolve to remain usable in the future. Digital trends and breakthroughs change rapidly and the framework would need to co-evolve to remain relevant.

This chapter concluded the study and presented an overview of the findings of this research. The chapter commenced with a research summary which elaborated on each of the four Parts of the Research Design. The research objectives were all reached successfully and their references within this document were indicated. The contributions of this study were also discussed. Following the discussion on the research contribution, the limitations of the research were listed. The chapter concludes with recommendations for future work.

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Appendix A: Systematic literature review primary studies

Number	Author(s)	Title	Reference
1	Davis J.P.	The Group Dynamics of Inter-organizational Relationships: Collaborating with Multiple Partners in Innovation Ecosystems	[100]
2	Hallingby H.K.	Key success factors for a growing technology innovation system based on SMS Application-to-Person in Norway	[87]
3	Ansari S.S., Garud R., Kumaraswamy A.	The disruptor's dilemma: TiVo and the U.S. television ecosystem	[82]
4	Jha S.K., Pinsonneault A., Dubé L.	The evolution of an ICT platform-enabled ecosystem for poverty alleviation: The case of Ekutir	[88]
5	Surie G.	Creating the innovation ecosystem for renewable energy via social entrepreneurship: Insights from India	[83]
6	Adner R.	Ecosystem as Structure: An Actionable Construct for Strategy	[81]
7	Facin A.L.F., De Mesquita Spinola M., De Vasconcelos Gomes L.A.	The impact of platforms in product development: A case study in the Brazilian software industry	[89]
8	Lusch R.F., Nambisan S.	Service innovation: A service-dominant logic perspective	[90]
9	Bosch-Sijtsema P.M., Bosch J.	Plays nice with others? Multiple ecosystems, various roles and divergent engagement models	[104]
10	Eaton B., Elaluf-Calderwood S., Sørensen C., Yoo Y.	Distributed tuning of boundary resources: The case of Apple's iOS service system	[91]
11	Barrett M., Davidson E., Prabhu J., Vargo S.L.	Service innovation in the digital age: Key contributions and future directions	[92]
12	Bosch-Sijtsema P.M., Bosch J.	Aligning innovation ecosystem strategies with internal R&D	[103]
13	Gawer A., Cusumano M.A.	Industry platforms and ecosystem innovation	[79]
14	Koch S., Kerschbaum M.	Joining a smartphone ecosystem: Application developers' motivations and decision criteria	[85]
15	Elaluf-Calderwood S.M., Eaton B.D., Sørensen C., Yoo Y.	Control as a strategy for the development of generativity in business models for mobile platforms	[94]
16	Rao B., Jimenez B.	A comparative analysis of digital innovation ecosystems	[86]
17	Wang T.J., Chang L.	The development of the enterprise innovation value diagnosis system with the use of systems engineering	[84]
18	Selander L., Henfridsson O., Svahn F.	Transforming ecosystem relationships in digital innovation	[106]
19	Rong K., Shi Y.	Renew business ecosystem: A comparison study between traditional and Shanzhai network	[105]
20	Scholten S., Scholten U.	Platform-based innovation management: Directing external innovational efforts in complex self-organizing platform ecosystems	[80]
21	Xu X., Venkatesh V., Tam K.Y., Hong S.-J.	Model of migration and use of platforms: Role of hierarchy, current generation, and complementarities in consumer settings	[95]
22	Parker G., Van Alstyne M.	Innovation, openness & platform control	[108]
23	Olsson U., Börjesson M.	Leveraging open source in commercial service layer development - A case study	[101]
24	Parker G., Van Alstyne M.	Managing platform ecosystems	[110]
25	Iyer B., Davenport T.H.	Reverse engineering Googles innovation machine	[98]
26	Sarkar R., Prabhakar T.V., Chatterjee J.	Towards digital ecosystems for skill based industrial clusters: Lessons from the 'digital mandi' project	[111]

Appendix B: Inventory framework: Concept glossary

Platform owner			
Category	Concept	Description	Key references
Strategy	Goals	The firm should establish the long-term and short-term goals for the firm and the ecosystem and align their partners accordingly.	[152]
	Openness	This refers to the amount of information shared about the platform with outsiders. Openness can refer to the extent to which the platform owner decides to make platform aspects available such as open standards, open formats and open source.	[135] [85]
	Measurement	A measurement initiative could be established such as defining KPIs and continuously monitoring the current state of the firm and its ecosystem as well as predicting its future states.	[198]
	Responsibility	The responsibility of the participants within the ecosystem should be predetermined/established as it will form part of the decision criteria as to why actors choose to join the ecosystem.	[124]
	Entry barriers	Entry barriers enable a sense of control regarding who enters the ecosystem. These barriers can either be too high (risking possible innovation) or too low (reducing quality).	[135] [85] [51]
	Core interaction	By establishing a core interaction, it establishes focus and it also allows for specialisation of the firm in terms of this core interaction.	[11]
	Scope	Identifying the scope refers to identifying the target market, the product itself, the software delivery model and expectations. An Industry capability stack [143] is a useful tool to define what the firm will and will not do. The platform owner should be explicit when defining both the ecosystem and its governance strategy.	[154] [137] [198]
	Role in ecosystem	The platform owner should establish their role within the ecosystem and should be vigilant against leaning towards a dominator strategy.	[12]
	Stability	The organisation should have a sense of stability regarding direction, company vision and strategy as well as its relationships with employees and ecosystem actors. The reason for this is that it influences how external actors perceive the platform firm and therefore the ecosystem.	[154]

	Define external environment	The ecosystem does not function in a bubble and the platform owner should be aware of its complete environment including the suppliers, its competing ecosystems, stakeholders and laws and regulations that are applicable to the ecosystem.	[135]
	Project distribution barriers	Within the defining of the scope and target participants, the platform owner should consider the technical and socio-organisational barriers for coordination and communication in projects that are geographically distributed.	[127]
	Decomposition	Decomposition refers to the hierarchical decomposition of the ecosystem into subsystems.	[124]
Governance structure	Licensing	The licencing agreements that the developers have to agree to in order to gain access to the platform.	[80]
	Intellectual property (IP)	IP rights should be established in such a manner as to facilitate third-party innovation and not limit it.	[137] [2]
	Standards	Standards facilitate interoperability between organisations, devices, technologies or data formats. The necessary standards should be enforced by the platform owner.	[12]
	Decision rights	It is important to establish which actors in the ecosystem have authority in decision-making and to what extent.	[124]
	Proprietary vs shared	This refers to the ownership of the platform (not to the architectural openness of the platform software).	[124]
Internal organisation	Structure	The actual structure of the platform firm should be carefully planned. For example separating the groups dealing with customer support and those developing complementary products on the platform.	[137]
	Conflict management	The tensions and conflict that could arise within the platform firm. These situations can occur when assisting external developers with their development process while internal groups are also developing complements.	[137]
	Processes	These internal processes refer to set processes within the firm such as having meetings with different firm levels to set goals and develop strategies. These might also include processes for dealing with conflicts that might arise in different units of the firm.	[137]
	Culture	A culture of debate and discussion should be encouraged as it results in dealing with conflicts in a healthy manner and also encourages innovation.	[85] [137]
	Vision	The vision refers to the envisioned future state of the firm and/or ecosystem which should be articulated. It could encourage actors to enact in this vision. Not only for the platform owner, but could also to motivate external actors sharing the vision to join the ecosystem.	[154] [79]

	Values & Beliefs	The platform owner should establish its values and beliefs and aim to foster common values and beliefs within the other ecosystem participants.	[124]
Architecture	Scalability	The platform should be designed to adapt to user demand fluctuations. The firm could also leverage the ecosystem capabilities to add to scalability and adaptability.	[137]
	Stability	Stability specifically refers to the stability of the platform architecture and interfaces. As the connecting point with the developers, the interfaces should be stable.	[93] [127] [109]
	Modularity	Modularity entails how certain components of a system can change without affecting the rest of the system. A modular architecture is recommended as it facilitates innovation.	[124] [143] [79] [109]
	Interfaces	The use of standard interfaces such as APIs to standardise how different modules access and interact with the platform.	[124] [12] [109] [93]
	Toolkit	The toolkit (such as SDK) is the interface software provided by the platform owner that enables the developers to successfully innovate upon their platform.	[85] [156] [15]
	Openness	The level of openness of the architecture should be decided upon by the platform owner. It refers to the extent to which outsiders can access the different layers of the platform and change some of the functionality for their own use. Openness is a balance between allowing developers to effectively develop quality complements and not opening the platform to such an extent as to allow duplication of certain platform elements or unplanned competition to emerge.	[158] [150]
	Feedback methods	The platform owner should consider implementing both developer and end-user feedback methods. This could possibly reduce information asymmetry (in cases where developers and platform owner compete, or competition between developers).	[12] [80]
	Programming languages	The programming languages used and required to develop complements on the platform is a decision the platform owner has to make as it has an effect on the adoption of the platform.	[85]
	Marketplaces	The marketplaces refer to the application portals where developers distribute their products and services and where end users can purchase it. The platform owner should be aware of the different marketplace requirements.	[85]
	Data privacy and security	Depending on the target market, the platform owner needs to take extensive measures to ensure data privacy and security. For example, especially in health – related markets, extreme measures should to be taken to ensure privacy and security of data.	[2]

	Providers	Depending on the nature of the platform, it might have to be able to run on a specific hardware device (even other software (middleware), depending on type of platform) and the platform owner should ensure interfacing is possible.	[11]
Operational	Marketing & Sales	An effective marketing of the platform as well as sales approach can increase the growth of the ecosystem.	[135] [152]
	Research & Development	Especially in the IT industry, the rate of new technologies and concepts require constant R&D for new, innovative concepts to ensure that the ecosystem evolves. This can also be done in correspondence with the developer firms.	[135] [152]
	Support & Services	Adequate support and services should be available to help developers with initial set-up as well as other issues regarding the platform.	[135] [152]
	Market management	Market management forms a foundation of the competition within the ecosystem and the platform owner should create and manage trust, define the market governance structure, design a flexible market and leverage the participants in the ecosystem.	[137]
	Reputation management	The reputation of the firm directly influences the attraction of stakeholder and ecosystem participants.	[154] [51] [79]
	Risk management	Risks can be shared amongst all partners as a method of risk management. This might include monitoring of potential risks, deciding to widen the ecosystem scope or monetary investments to evolve the technology.	[210] [79]
	Securing	Securing is the continuous process of modifying the level of control of the platform and can be related to managing the potential risks the platform and other actors may face.	[15]
	Resourcing	Resourcing is the continuous process whereby the scope and diversity of the platform are increased enabling new resources, knowledge and capabilities within the ecosystem.	[15]
	Investments	The firm's revenue model should include the re-investment of profits into both the platform and the complements.	[132] [79]
Developer			
Category	Concept	Description	Key reference(s)
Entry barriers	Homing costs	These are the costs associated with joining the ecosystem. It could include platform adoption, operating and opportunity costs such as access fees for access to the platform and its interfaces.	[124]

	Stickiness/exit barriers	These aspects define how hard it is for developers to leave the ecosystem.	[116]
	Fairness	Fairness is a key attribute contributing to the sustainable relationships within the ecosystem. Fairness can also be related to justice which implies fair dealings within the ecosystem whether it be monetary or proprietary.	[156] [2]
	Market size	The market size refers to the 'footprint' of the platform ecosystem including the number of users within the ecosystem and the potential market that a developer can reach when joining the ecosystem.	[85] [156] [132]
	Marketplaces	Marketplaces are the application portals where developers upload their products and services and from where the end user can obtain these. Depending on the platform's nature, the platform might have to define which marketplaces their platform can comply with.	[132]
	Diversity	Diversity refers to both the variety in developers as well as the variety of the type of apps developed within the platform ecosystem and is a key component in a healthy, evolving ecosystem.	[133]
	Value creation	This refers to the extent that the platform enables the actors within the ecosystem to co-create and share value. The value creation opportunities within the ecosystem is a vital consideration for external developers as it reflects their potential success as a participant within the ecosystem.	[131] [80]
	Value distribution	This is the term given to describe in what manner the platform owner aims to divide the value (profits) throughout the ecosystem. An example would be whether the platform owner takes a percentage of developer profits, or if it is expected of the developer to pay a fixed amount that is not dependent on developer profits.	[15]
	Trust	A key aspect in management and sustainability of platforms is establishing trust with developers. The platform owner often acts on behalf of the ecosystem and therefore to an extent carries the fate of the developers.	[143]
	Reputation	The platform leader should have a reputation of not stepping out of their product or services scope boundaries into the territory of the developers.	[143]
	Credibility	A platform firm should invest in its brand credibility (believability) which in simple terms means that the platform owner does what it sets out to do. This can be directly linked to the loyalty of developers to the platform.	[156]
	Loyalty	Within the 'ecosystem war', platform owners should invest in encouraging loyalty of the developers to remain within their platform ecosystem.	[156]

	Accessibility	The platform accessibility is related to the openness of the platform. This refers to the access that developers have to different levels of the platform and will be a key determining factor on whether to join a certain platform ecosystem or not.	[158]
	Openness	The openness of the platform can be related not only to the architecture but also to the perceptions of the platform in terms of reputation, transparency and rights and is therefore a key aspect developers consider when deciding to join the platform.	[51]
	Programming languages	The programming language(s) required for using the platform is a consideration when joining an ecosystem. It may require the developers to learn a new language or they can simply apply the languages they are familiar with.	[85] [156]
	Toolkit quality	The toolkit (e.g. SDK) quality is one of the most important aspects in determining the loyalty of developers to a platform as it is linked to the quality of products and services they can deliver.	[156] [85]
	Developer type	Mobile apps can either be native (run on OS and adapted for different devices), web-based (accessed via web-browser) or hybrid (web-apps in native browser). It should also be established whether the platform owner scope allows for enterprise apps, commercial apps or apps for personal use. Basically the core proposition of each complementary firm.	[157]
Governance structure	Intellectual Property	The platform leader should help the developers to protect their IP and should put their own interests aside for that of the ecosystem.	[79] [137]
	Data privacy and security	The personal information of the developers should be protected and the platform owner has to ensure the developers can secure the data of their products and/or services.	[2]
	Control mechanisms	Control mechanisms put in place by the platform owner which should encourage desirable behaviours in the developers. These could include market control, restrictive control, motivational control (funding, support systems), co-regulative control (development guidelines, rules and tools).	[124] [80]
	Design rules	These are the rules that the developers need to obey when using the platform to develop their own products and services. These rules need to be stable (all developers face same conditions) yet versatile (developers should still be able to innovate). The platform owner could possibly provide developer training for example.	[124]
	Goal congruency	The compatibility of the goals of the developer firms with that of the platform owner and ecosystem should be encouraged to reduce future tensions, competition as well as encourage innovations within the ecosystem.	[80]

Ecosystem	Tensions	Tensions between platform owner and complements. These tensions can occur when risks have to be taken within the ecosystem, when the objectives of the ecosystem participants differ or when competition occurs within the ecosystem.	[124] [137]
	Interest of partners considered	The platform owner should consider the interests of all partners within the ecosystem, not only their own.	[210]
	Managing network effects	The basic principle of network effects describes that the more developers join the ecosystem and develop complementary products and services using the platform, the more valuable the platform becomes and will therefore attract more complementary firms. Therefore the platform owner should be aware of the dynamics of these network effects and should generate methods of encouraging platform network effects and be vigilant for negative network effects.	[101] [80]
	Encourage innovation	The platform owner should actively encourage innovation within the ecosystem, especially from the developers, as a source of user innovation.	[51] [80]
	Co-evolution	The platform owner should focus on co-evolving with the other actors in its ecosystem. This includes aspects such as re-evaluating ecosystem goals and platform markets.	[133]
Architecture	Interfacing	The ability to interface with other components or systems. In other words, being compatible. If the platform is compatible, it can interface with different platforms. An example is a document generating app being able to interface with Dropbox.	[156]
	Feedback	The platform owner should enable the developers to provide feedback regarding the use of their platform. This forms a key part in the evolution and the continuous improvement of the platform.	[152]
	Hardware and software integration	Different hardware components might require specific adaptations in software (for example, screen resolution of different mobile phones). The platform owner should state whether development is possible for a variety of devices or not.	[85]
	Marketplace requirements	In order to enable the developers to develop better quality apps, the platform owner should be aware of the marketplace requirements.	[85]
	Leveraging	The firm should also leverage the ecosystem capabilities to add to scalability and adaptability.	[137]
	Poor developer practice	This refers to aspects such as reduction in testing procedures of apps driven by developer laziness. Developer training regarding platform use might be a solution to reduce this concern.	[211]
	Vulnerability	Possible weak points in the software should be eliminated, especially when working with sensitive data.	[211]

Standards & Models	App development guidelines	Platform owners should be aware of the tools that major firms such as Apple (Apple HIG) and Google (Android) provide for guiding the app-development process.	General
	Partnership model		[51] [116]
	Boundary resources model		[15]
	Open software enterprise model		[152]
	SECO-SAM (Software ecosystem assessment model)		[135]
Customer support	Debugging aids	Debugging aids should be included in the tools provided to the app developers.	[156]
	Testing support	Testing applications in terms of mobility, network availability, sensors, etc., are a major challenge for developers. Possible platform supported tools can be provided or recommended, such as existing emulators (mimicking of hardware and software environments) and simulators (software environment).	[157]
	Online communities	Connectedness amongst the developers as 'niche players' in the ecosystem should be encouraged. This could result in community building within the ecosystem and could potentially increase innovation.	[135]
	XMTs	Cross development tools (XMTs) are used to create apps for different operating systems using the same code.	[85]
	Ability to innovate and share	By sharing knowledge within the ecosystem, it can encourage innovation and lead to higher productivity. The level of control within the ecosystem is therefore a balance as control is needed, but the platform owner should not restrict the complementary firms to such an extent as to limit their ability to innovate.	[135]
	Developer satisfaction	Developer satisfaction is key to ensure loyalty to the platform. These aspects also include 'soft' aspects such as the process being fun, intellectually stimulating, improving skills etcetera.	[85] [156]
	Convenience of migration	Effort should be taken to reduce time, effort and budget requirement for developers migrating from different platforms and ecosystems.	[157]
	Internal customer support	The platform owner should have a dedicated team to supply the platform users with the required support (support teams for example) regarding the use and debugging of the software platform.	[152]
Control	Monitoring	The platform firm should monitor all actors in the ecosystem, evaluating their performance, making decisions and taking actions based on the observations.	[128]

	Track user loyalty	The number of active developers and their loyalty could be tracked as this can be a key indication of a more attractive ecosystem (competition).	[132]
	Review process	The platform owner should carefully review the products and services that are developed on their platform as a method of quality control.	[196] [156]
End user			
Category	Concept	Description	Key references
Context of use (important as the platform owner might also be developing apps (internal platform))	Organisational context	The organisational context should be considered as to ensure the work and safety rules and regulations are not violated with the use of the app.	[164] - Obtained from ISO 9241-11 (1998)
	Physical context	The physical surroundings of the user such as possible noise, ambient conditions, health and safety issues etcetera.	[164] - Obtained from ISO 9241-11 (1998) [159]
	Social context	The social context refers to aspects such as whether assistance is available, is the envisioned environment for a single user or multi-users.	[164] - Obtained from ISO 9241-11 (1998)
	Task characteristics	The task characteristics include the frequency of use of the app and the corresponding duration, physical and mental demands and the app complexity.	[164] - Obtained from ISO 9241-11 (1998) [159]
	User characteristics	It is vital to be attentive to user characteristics. They include the languages, the computer/digital skills, the reading level, the level of experience etc., which will inherently determine the success of the app.	[164] - Obtained from ISO 9241-11 (1998) [160]
	Country differences	Firstly, app user behaviour differs in different countries in terms of what type of apps users prefer, the features they dislike in apps or to what extent they give app feedback (see reference). Secondly, each country has different laws and regulations related to data, content being displayed, freedom of speech etc.	[168]

	Geographical context	The geographical context of app use refers to the network coverage available (2G, 3G, 4G, etc.). This should be considered when designing the app as it will affect how the app is presented.	[159]
Quality control (as an ecosystem perspective is undertaken, the products of developers affect the ecosystem)	Usability	Usability attributes and metrics form a large part of the literature regarding app development and use. Various standards and models include usability attributes such as efficiency, effectiveness, satisfaction, reliability, memorability and low error rate.	IEEE standards, ISO standards, Other literature models [160]
	Learnability	The level of ease with which the app can be used to its fullest extent. This could, for example, be a determining factor if time is crucial to the customer.	[164]
	Understandability	Understandability includes aspects such as navigation through the app levels, logic of using the app, confusing text or button layout, user guidance, simplicity, etc.	[164]
	Reliability and performance	The platform owner should ensure on their part the smooth, error-free operation of apps that are stable, reliable (especially in healthcare) and can meet the performance requirements of the developers and end users.	[212] [164]
	App deployment	In the case of enterprise apps for example, it might be necessary to assist the end user with guidelines for using the app.	General
	User requirements	The developer of the app should conduct an investigation to determine the user requirements of the proposed app as this will provide the ability to evaluate the success of the app – how well it meets the user needs and requirements.	[168]
Feedback	User data feedback	In order to continuously improve the platform, end-user feedback should be enabled. This can be done through mining marketplace data, incorporating activity logs, through surveys, customer feedback or controlled-environment experiments.	[170] [196]
	Quick updates	The software should enable the quick updating of apps if major issues are reported via feedback. Feedback could even lead to the platform software being updated.	General
Standards & Models	Laws and regulations	The platform owner may decide to invest in checking if the apps developed on their platform comply with the known applicable laws and regulations. If the developers do not comply, it may have a negative effect on the ecosystem as a whole and on the platform reputation. For example FDA laws in USA for the healthcare industry, or Appstore-specific rules.	[168]

	ISO Standards	Or any standards related to usability or other context-specific aspects should be obeyed.	General
	Apple HIG	Guidelines provided includes platform characteristics, human interface principles and user experience guidelines.	[167]
	Android UIG		[166]
	Usability Engineering	Usability engineering by Jakob Nielsen	[165]
	MUSiC	Metrics for Usability Standards in Computing	[164]
	QUIM	Quality of Use Integrated Measurement model	[164]
	PACMAD	People At The Centre of Mobile Application Development	[159]
	GQM Approach	Goal Question Metric Approach (for software engineering)	[213]
Attractiveness (first impression which is important for competitive edge)	Visual aspects	The aspects such as the app icon and the visual layout of the app interface are important aspects not only if selling the app in a marketplace, but even for enterprise apps as this is directly related to the user experience of the app. This can also include aspects such as app colours and fonts.	[168] [164]
	Level of exposure	This aspect can be related to network effects and refers to the exposure of the app in terms of the amount of other users. App users consider the popularity of the app when buying or using a specific app.	[168]
	Pricing	Much thought needs to be placed on the pricing of the apps and to relate this to the end-user target market.	[168]
	User comments	The ability for app users to comment on aspects such as app crashing, it being too slow, difficulty of use or unnecessary features.	[214] [168]
	Other marketplace related factors	There are several literature guidelines presenting the strategies that should be followed regarding success in the marketplace (Appstore for example). This includes the app description, screenshots, designing of more appealing apps, etc. The marketplace dynamics are outside the scope of this research.	[168]
	Pricing guidelines	The platform owner can possibly provide guidelines in terms of pricing of apps based on their platform. If the apps are too expensive, no one will buy them and therefore it has an indirect effect on the platform.	General

Appendix C: REC Ethics participant consent form

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STELLENBOSCH UNIVERSITY

CONSENT TO PARTICIPATE IN RESEARCH

Dear Prospective Participant

My name is Hilde Herman and I am currently a MEng (Engineering Management) student at the Department of Industrial Engineering at Stellenbosch University. I would like to invite you to participate in a research project entitled "Developing a framework for technology platform design, development and implementation in the South African health context."

Please take some time to read the information presented here, which will explain the details of this project and contact me if you require further explanation or clarification of any aspect of the study. Also, your participation is **entirely voluntary** and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part.

1. Introduction

Significant innovation and changes are needed to address the healthcare related issues faced by South Africa and to rectify the system to ensure all citizens have equitable healthcare. Technology platforms could provide an innovative way to address some of the primary healthcare challenges. There seems to be little research on the implementation of these platforms in the African or developing country context and there are still several barriers to overcome before full-scale adoption of platforms as seen in other industries can take place.

In order to utilize the potential of technology platforms, a framework for the design, development and implementation of such technology platforms specifically tailored to the South African health context are to be developed. The researcher hopes that this will increase the uptake of technology platforms as innovative solutions to the healthcare problems.

2. Purpose

The main aim of this study is to develop a management tool for the design, development and implementation of technology platforms in the South African health context. The researcher envisages that the framework will aid in increasing the uptake of technology platforms to provide much needed solutions in healthcare. This study also adds to the literature on technology platforms and their corresponding platform ecosystems and how to ensure the health of the complete ecosystem. The framework/tool to be developed requires validation by experts in the field and therefore requires a practical component through surveys and interviews.

3. Procedures

As this study is qualitative of nature, participants will be asked to engage in a discussion concerning technology platforms and its functioning. Ideally, these discussions are to be held in person, or via Skype.

Volunteers of this study will be asked to either complete the online survey to the best of their ability, or join in an interview discussion or both. The interview will be kept within an hour time limit.

4. Time

The interview will be a maximum of one hour. If more time is required, the principal investigator will contact the volunteer and request a follow-up interview.

5. Risks

The researcher is unaware of any risks or discomforts that may be caused and will try their best to create an atmosphere that is conducive to learning. The participant will not be threatened by any physical or psychological risks during the interview.

6. Benefits

Participation in this study is done on a voluntary basis as no payment will be given to participants. The participants will therefore not benefit directly from the study, but will add to the literature on technology platforms which can be used in providing innovative solutions to healthcare problems.

7. Confidentiality, Recordings and Data Storage

Any information that is gathered for use in this study that can is related to you will remain confidential and will not be disclosed without your consent. Confidentiality of data will be maintained as described below.

The interviews will be conducted via Skype or face-to-face depending on interviewee availability or preference. The interview will be guided by pre-defined questions to initiate the discussions. The interviews will be voice-recorded and notes will be made by hand if necessary to allow the researcher to refer back to the interviews if required.

The recordings of the interviews will be stored on a USB drive and will be locked away at the Engineering Faculty of Stellenbosch University. Access to the office at the Engineering faculty is only via card access and CCTV cameras are at each entrance. The computer used to work with the data is password protected.

The data from both the interviews will be stored online in a folder which is password protected. The confidentiality and terms of engagement as well as the company confidentiality will be discussed prior to the interviews between all parties. Participants will be anonymised throughout the study documentation. No personal information of any participant will be disclosed. Each participant will be given an identification code to ensure anonymity. Interviewee direct quotes will only be used in the thesis document with the complete permission of the interviewee.

Any future use of data obtained from the surveys and/or questionnaires will only be done with the permission of the relevant participants.

8. Participation

The participation in this study is completely voluntarily and the participant is free to withdraw from the study without any negative consequences. The participants are also free to refuse to answer questions they do not feel comfortable with. If you wish to withdraw, I will remove all your data and replace your position with a similar participant.

If you have any questions or concerns about the research, please feel free to contact me, the Principal Investigator at 0832766825 or 17096059@sun.ac.za. The supervisors, Saartjie Grobbelaar and Calie Pistorius can be contacted at ssgrobbelaar@sun.ac.za and calie.pistorius@deltahedron.co.uk.

RIGHTS OF RESEARCH PARTICIPANTS: You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research participant, contact Ms Maléne Fouché [mfouche@sun.ac.za; 021 808 4622] at the Division for Research Development.

You have right to receive a copy of the Information and Consent form.

If you are willing to participate in this study please sign the attached Declaration of Consent and email it to the investigator.

DECLARATION OF PARTICIPANT

By signing below, I …….. agree to take part in a research study entitled…… **……** and conducted by …… (Name of Researcher)

I declare that:

- I have read the attached information leaflet and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions and all my questions have been adequately answered.
- I understand that taking part in this study is **voluntary** and I have not been pressurised to take part.
- I may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- I may be asked to leave the study before it has finished, if the researcher feels it is in my best interests, or if I do not follow the study plan, as agreed to.
- All issues related to privacy and the confidentiality and use of the information I provide have been explained to my satisfaction.

Signed on ……..

……

Signature of participant

SIGNATURE OF INVESTIGATOR

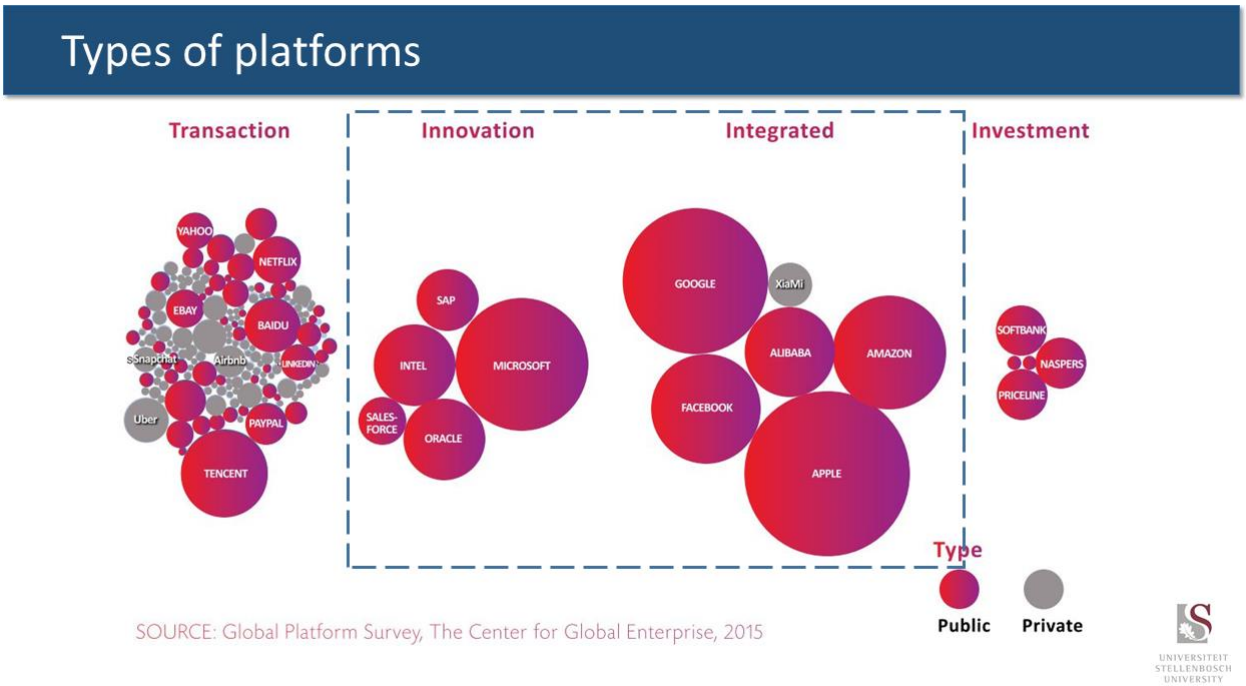
I declare that I explained the information given in this document to _____ [*name of the participant] [H*e/she] was encouraged and given ample time to ask me any questions. This conversation was conducted in [*Afrikaans/*English/*Xhosa/*Other*] and [*no translator was used/this conversation was translated into* _____ by _____].

_____ _____

Signature of Investigator Date

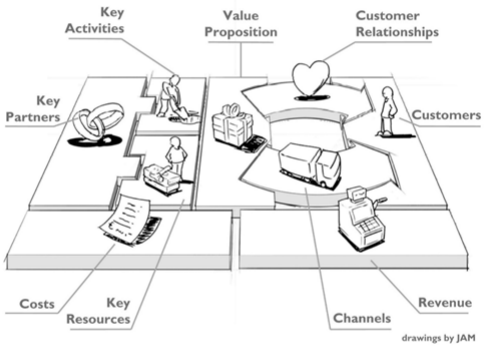
Appendix D: Semi-structured interview assisting elements

D1: Interview slideshow



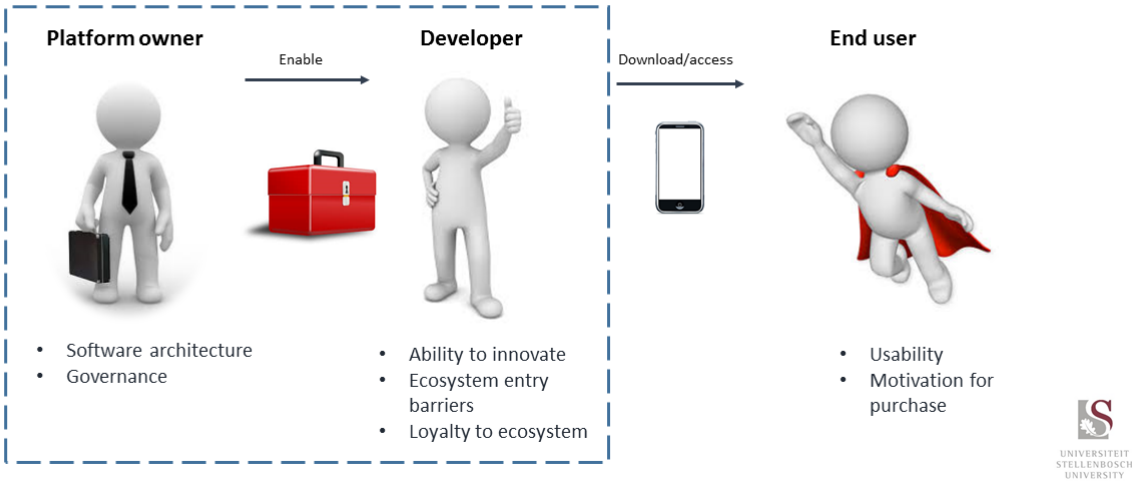
The proposed platform management tool

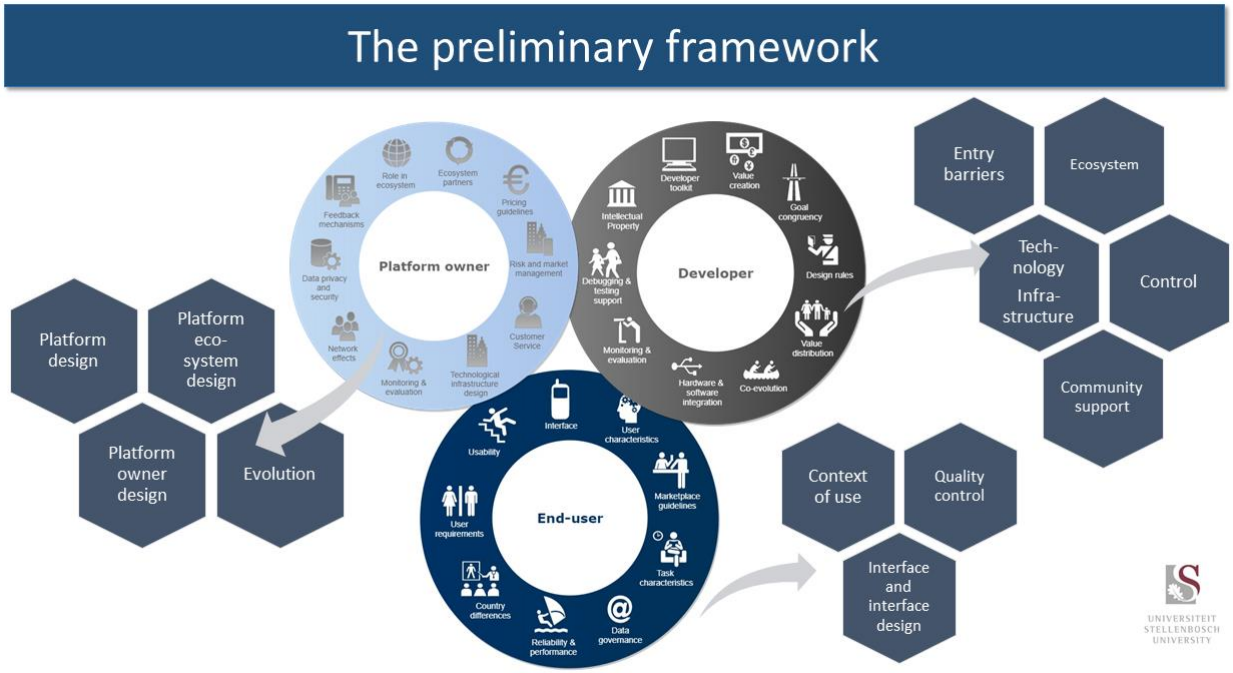
- Inspired by the **Business Model Canvas** initially proposed by Osterwalder [1]
- Aid in organisational innovation
- Gives structure to an idea
- Draw out important risks and assumptions
- Aligning activities by illustrating potential trade-offs
- Clear and simple to use
- Asks key questions to direct strategy



Elements of the proposed framework…

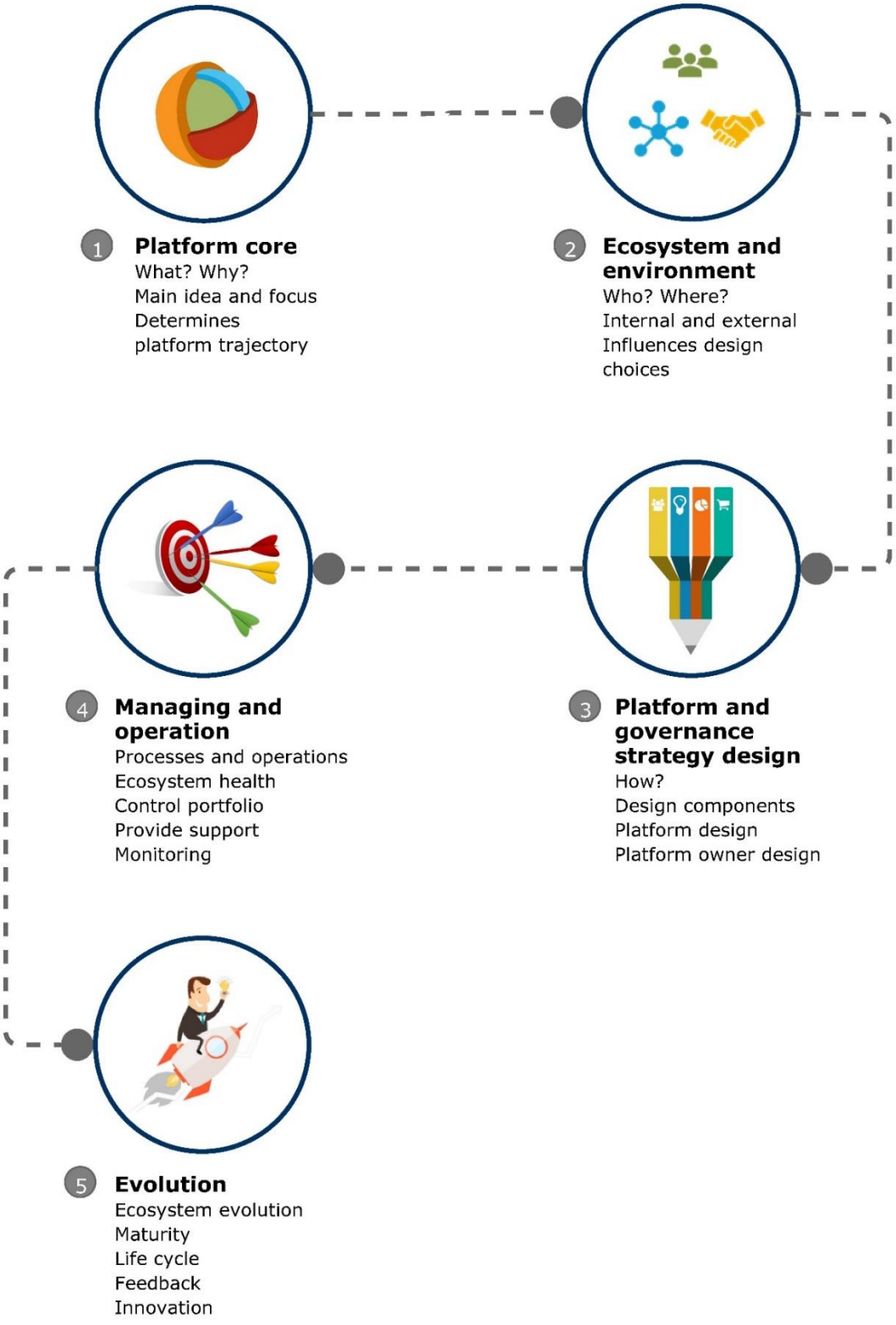
- Look beyond the only the technology, also to the people involved





D2: Interview roadmap and outline

Platform management tool: Interview roadmap



Interview Outline: Platform Owners

- Thank you for participating in this interview as a part of the research towards my Master's degree in Engineering Management with the title "Development of a framework for the design, development and implementation of technology platforms in the South African Health context."
- The aim of this interview is to provide the researcher with practical insight and feedback on the framework developed to aid in the design and development of technology platforms within their platform ecosystems. The interview with a specialist in the field will provide validation of the usability and completeness of the framework.
- In order to document this interview for future reference, a recording of this interview will be made. After the completion of the interview, the researcher will type out the interview and forward the document to ensure all information is correct. All names and personal details will be kept anonymous.

  - Please fill out the consent form.
  - You can answer Yes/No, or choose to elaborate if you choose. I would prefer as much information as possible, but you are free to choose, or not to answer at all.

Platform management tool: Interview questions

What? Why
Main idea and focus

1 Platform core

Questions	Example concepts
What is the main aim or purpose of your platform?	Core functionality, core interaction
How does the platform create, capture, deliver and distribute value (also among ecosystem partners)?	Value creation and distribution
How is platform growth and evolution encouraged and navigated? (goals, scope, feedback mechanisms)	Goals, scope
Why is the platform valuable and useful and to whom?	Core interaction, core functionality, how do all actors make money

Who? Where?
Internal and external

2 Ecosystem and environment

Questions	Example concepts
Who would you consider are the main actors within your platform ecosystem and why?	Key actors, goal congruency, entry barriers, markets, market size, diversity, providers, barriers
What are the different roles within this platform ecosystem? (Your role as platform owner, decision rights, responsibilities)	Role, responsibility, decomposition, decision rights
How does the external environment in which the platform ecosystem operates influence its design and management? (trends, market and industry forces, emerging technologies)	Key trends, market and industry forces, competition, VC, providers, ME forces
How are potential users attracted and added to the platform ecosystem?	Entry barriers, markets, market size, network effects, goal congruency, ecosystem health

How?
Design components
Platform design
Platform owner design

3 Platform and governance strategy design

Questions	Example concepts
What are some of the major platform design considerations you would emphasise? (software, technology, activities, resources)	Stability, scalability, modularity, interfaces, interoperability, toolkit, openness, feedback, application types, languages, marketplaces, security, key activities (connectivity, storage), providers (HW and SW), measurement (KPIs), key resources (personnel, infrastructure, access, technology.)
What are some of the major data-related considerations with regard to all actors in the ecosystem? (security, privacy, encryption, storage, types, governance)	Data privacy and security, data types, data governance and storage, data quality
What revenue model or pricing strategy does the platform follow (for all actors in ecosystem)? (percentage of profit, subscription)	Monetization, pricing, IP, licensing, proprietary vs shared
How is the platform designed to consider the different contexts, specifications and requirements of the users?	• Geographical context, country differences, user, task characteristics, social, physical and organisational context, • Learnability, understandability, • testing support, debugging aids, migration convenience, • laws and regulations, standards, visual aspects, • level of exposure, user data feedback, • marketplace requirements (Appstore), • HW & SW, Interfacing/compatibility
Are the platform and governance strategies designed by taking into consideration the users' motivations to join/participate? (entry/exit barriers). If so, please elaborate.	• Sustainability, openness, accessibility, languages, toolkit, • Developer type, stickiness, homing costs, • Culture, conflict, processes, vision, values & beliefs

Processes and operations
Ecosystem health
Control portfolio
Support
Monitoring

4 Managing and operation

Questions	Example concepts
How do you define ecosystem health and how do you monitor and control the health of your platform ecosystem? (KPIs, health metrics)	Trust, reputation, credibility, loyalty, fairness, diversity, tensions, interests, network effects, innovation, co-evolution, role in ecosystem, health, stability, measurement, feedback
Do you as platform owner provide user support and if so, how?	Support & Services, internal customer support, developer satisfaction, deployment, online communities, developer satisfaction, innovate
What control mechanisms are implemented within the platform? (software, different users, rules)	Design rules, M&E, quality assurance, feedback, user best practice, loyalty, feedback, data quality, reliability and performance, vulnerability
What do you consider as vital processes or management areas in the operation of your platform?	Marketing & sales, risk management, reputation, investments, R&D

Evolution
Maturity
Feedback
Innovation

5 Evolution

Questions	Example concepts
How do you define sustainability of your platform and can this be related to platform design and/or management?	Sustainability
How does your platform evolve or add new functionalities?	Co-evolution, envelopement, securing, resourcing
How do you maintain competitive advantage in your industry? (competing platforms and ecosystems)	Key trends, market and industry forces, competition, Value Chain, ME forces
Do you consider feedback from users as an important evolutionary aspect? Please explain	Feedback methods, user comments